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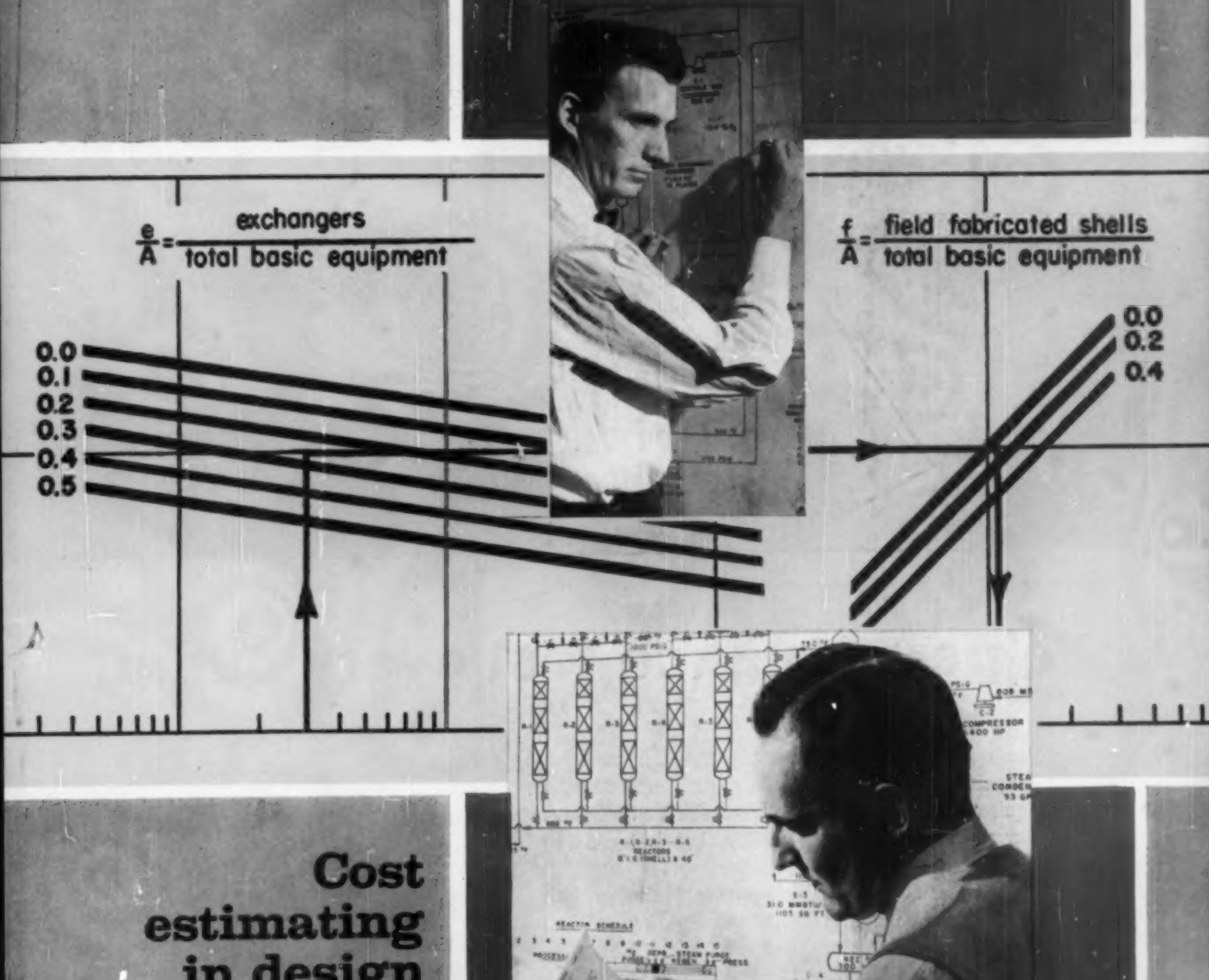
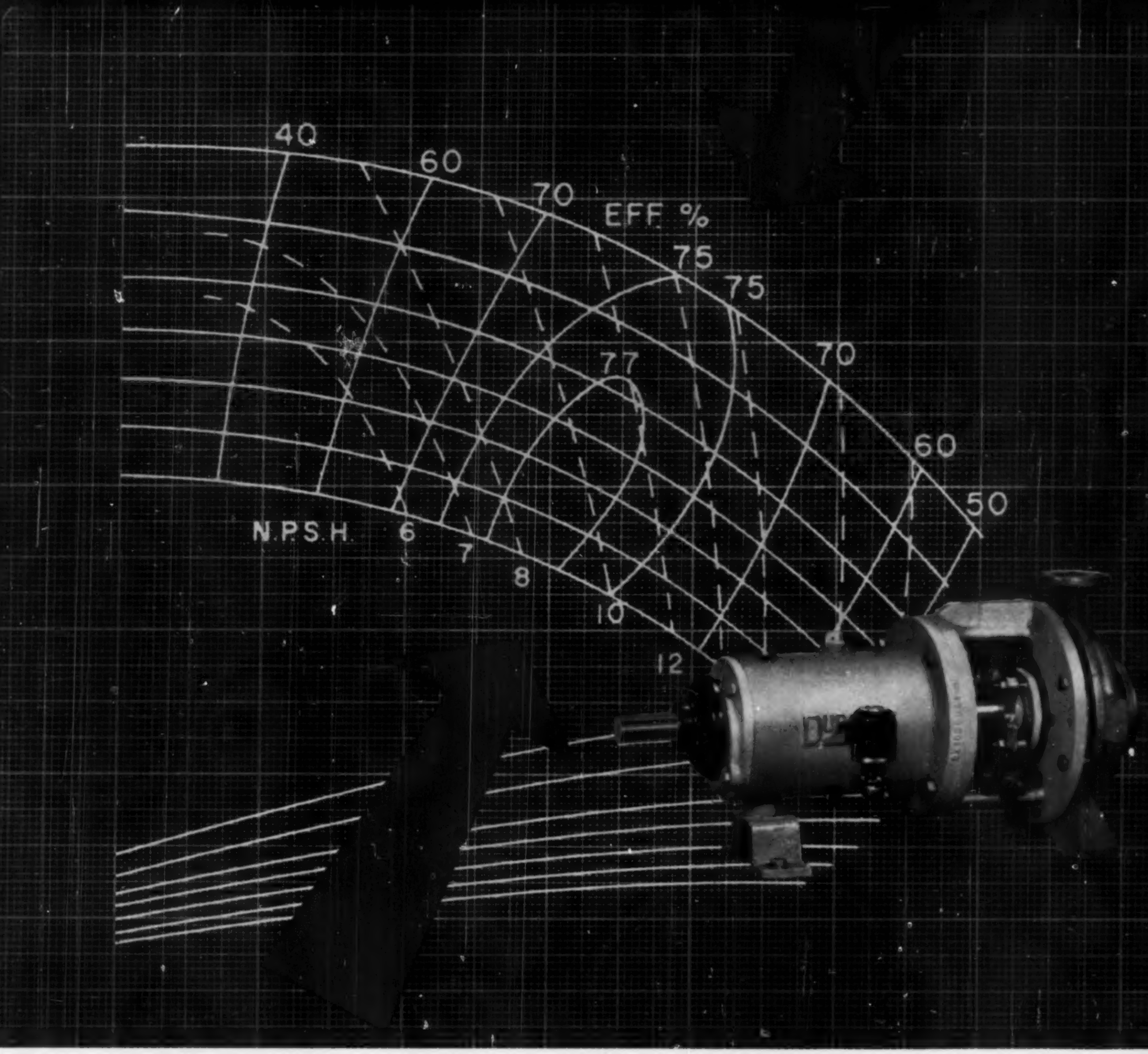
CHEMICAL ENGINEERING PROGRESS

DECEMBER 1960



Cost estimating in design and engineering

....page 37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CHEMICAL ENGINEERING PROGRESS

December 1960

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.... in this issue

CEP PERSPECTIVE

COST ESTIMATING

CEP feature

(Continued on page 5)

Our testing team works for you

Your requirements come first with our testing team. Working directly under our chief engineer, they check and double-check the fabrication work of our production crews. Your own men couldn't do a more faithful job. Come and see for yourself. Or write for Bulletins HE and CI.

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CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

DOWNINGTOWN IRON WORKS INC.

Hackney

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CEP .... in this issue

(Continued from page 3)

departmental features

Washington scope

Industrialization in Latin America

UNCERTAINTY IS THE ORDER of the day in Washington. At this point the Presidential election is over. And overshadowing the admittedly important domestic problems, the problems of first importance to this government are the maintenance of America's world-wide military and economic supremacies.

Europe, for the moment, is more or less stable. Africa, while in dire need of industrialization, is expected by Washington sources to remain in such a disturbed state for so many years that commercial development there is not now worthy of consideration.

But even with all of the unrest in the Western Hemisphere, it is here where the U.S.A. will extend itself to the utmost to effect an industrial expansion. Already this government has started to create a good business climate for Latin American expansion, as reported in this column in October, there's a new $500 million fund authorized, but not yet appropriated by Congress, to finance a broad economic-social improvement program in Latin America. The Act of Bogota stipulates that this fund shall be administered by the new Inter-American Bank which has an additional $1 billion already pledged by its members for Western Hemisphere industrial development.

In addition, on November 8th, the International Development Assn., an affiliate of the World Bank for financing economic growth in less developed countries, began operation. IDA will provide financing to the less developed areas of the world included within its membership on terms which bear less heavily on the balance of payments of these countries than conventional loans. If all the members of the World Bank join IDA, its initial subscriptions would total the equivalent of $1 billion, of which over three-quarters would be available on a fully convertible basis.

To further foster vigorous inter-American commerce, the establishment of the Central American Bank for Economic Integration has been under discussion in Washington between the Ministers of Economy and other high officials of Guatemala, El Salvador, Honduras and Nicaragua and high officials of the U. S. Government during the past few weeks.

Last week:

Export-Import Bank of Washington approved a $1.5 million loan to the glass making firm Cristalerie Peldar, Limitada, of Bogota, Colombia, to be used for the purchase of U. S. glass-making equipment.

Development Loan Fund, Washington, approved a loan of up to $2.5 million to the Caja de Ahorros (National Savings Bank), an institution of the Government of Panama, to assist in financing a program for low-cost home ownership in Panama.

International Monetary Fund, Washington, has entered into a stand-by arrangement that permits the Government of Nicaragua to draw up to $7.5 million during the next twelve months.

The Government of Colombia entered into a stand-by arrangement with the International Monetary Fund, Washington, which authorizes drawings up to $75 million for one year.

The Export-Import Bank of Washington has announced authorization of a credit of $12 million to the Argentine steel producing firm Sociedad Mixta Siderurgia Argentina (SOMISA). The credit will be used to purchase U. S. steel making materials and equipment to help complete construction of SOMISA's plant at San Nicolas.

Industry too is doing its share toward Latin American industrialization:

Enthone, Inc., a subsidiary of American Smelting & Refining Co., New York, has licensed Butcher-Udylite de Mexico, S.A. de C.V., to manufacture, sell and service Enthone products.

Reynolds Metals Company, Richmond, Va., will build a $13.5 million aluminum reduction plant in Venezuela.

Refinacoes de Milho, Brazilian affiliate of Corn Products Co., New York, will build a $10 million corn wet-milling facility.

Merck & Co., Rahway, N. J., will build a $1 million plant in Mexico City.

Cerro de Pasco Corp., New York, is planning expansion of its zinc and copper plants in Peru amounting to $6,825,000.

Goodyear Tire & Rubber Co., Akron, Ohio, will build a $2.8 million expansion of Neumaticos Goodyear Sociedad Anonima, its subsidiary at Buenos Aires, Argentina.

—J. L. GILLMAN, JR.

For more information, turn to Data Service card, circle No. 59

Water was scarce . . .
and the tubes were clogging up something awful!

The material was a 13,500 lb/hr shellac soda ash solution which required rapid cooling from 200° to 70° after de-waxing. A shell-and-tube was bogging down the whole operation with frequent clogging. Lack of water also focused attention on cooling efficiency.

A single section De Laval P-12 Plate Heat Exchanger did the job using less of the 60° cooling water than product stream! The 10° differential indicates the transfer efficiency. Cleaning became a quick and easy operation because the stainless steel plates opened in a moment. The illustration shows how compact this De Laval P-12 Plate Heat Exchanger is.

In another application, the heating of a latex solution caused coagulation that made the use of tube and shell type units impractical. Here the stream was over 250,000 lbs/hr and a two-section De Laval P-15 Plate Heat Exchanger handled the heating requirements easily and offered a practical and inexpensive solution to the clean-up problem.

De Laval offers the widest range of plate heat exchangers available. Our experience can help you.

THE HEAT EXCHANGER'S HEAT EXCHANGER

"Master your craft and you become known, for example, as 'the ballplayer's ballplayer' or 'the comedian's comedian.' There's a rumor (we're spreading it!) that De Laval Plate Heat Exchangers are the . . . you guessed it! Because of their remarkable heat transfer efficiency, extreme compactness and ease of operation and maintenance, our plate heat exchangers are judged to be in a top rank by themselves. Two typical installations where they solved difficult problems are discussed here."

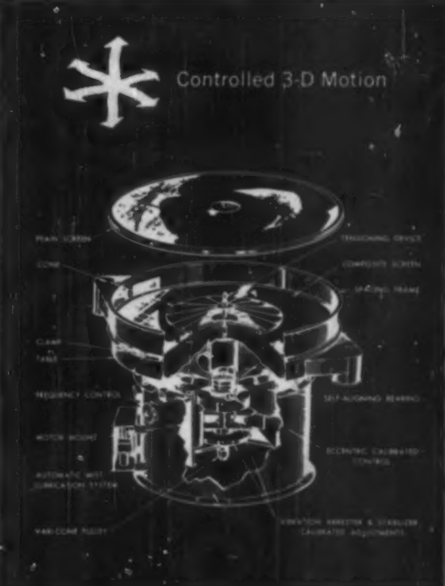
Fred Wheelwright, Industrial Sales Manager

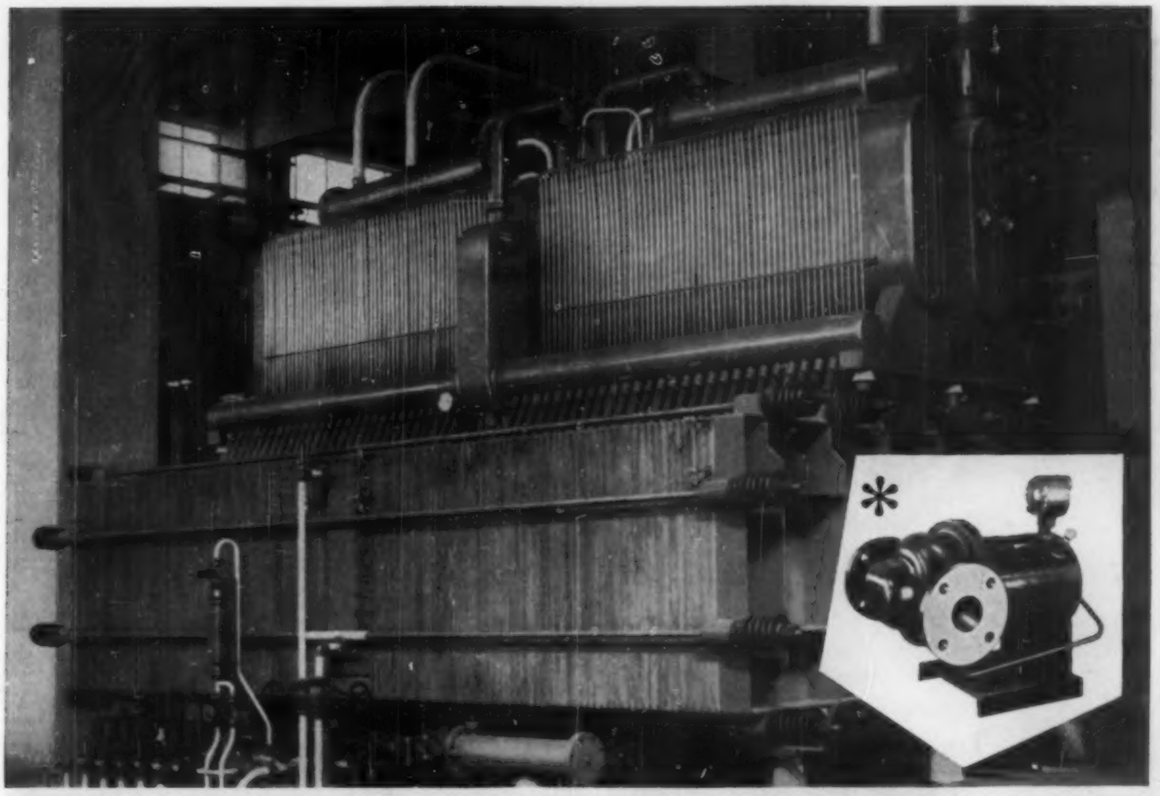
This vibrating screen shook up a pound of inquiries

Anyone using a screen separator is looking for a better one—it seems. Anyway, after the recent Chemical Show, we had on hand almost a pound of inquiry cards voluntarily filled out by bonafide prospects for our Syncro-Matic Screen Classifiers. It was a popular attraction, indeed.

Lookers became prospects when they found that our Syncro-Matic offered a full range of *three-dimensional* controlled motion ranging from gentle classification to turbulent sifting. The frequency is controlled by turning a knob, and the eccentricity control is calibrated for accurate pre-setting. Direct mechanical linkage *assures* a constant classifying action that, unlike gyratory types, does not dampen with heavy loading. Available screens, plain or composite, run the full range of commercial meshes and materials, and you can operate with one, two, or three decks. The base is practically vibrationless and operation is exceptionally quiet.

Soft foodstuffs, abrasive crystals, dry granules, liquids or slurries—all can be handled with excellent through-put and classifying efficiency. Write for details.





120 Chempumps Work 365 Days a Year In the World's Largest Electrolysis Plant

Leakproof Chempumps are eliminating pump maintenance worries and downtime at the world's largest water electrolysis plant, operated by Hindustan Chemicals and Fertilizers, Ltd., at Nangal, India. Enormous quantities of hydrogen are produced for use in much-needed fertilizers for Indian farmers.

One hundred and twenty double-suction Chempumps provide long, satisfactory life under conditions of infrequent maintenance—a vitally important contribution since the plant produces 800,000 cubic feet of hydrogen an hour and operates continuously 365 days a year.

Two Chempumps in each of the sixty 24′ x 18′ electrolyzers circulate the electrolyte, a 25-30% KOH solution, to the bipolar cells. These pumps combine motor and pump in one sealless unit that prevents leakage or contamination of the electrolyte through elimination of conventional seals and stuffing boxes . . . and assures a continuous, pure supply of electrolyte to the cells.

The Hindustan Chempumps have a capacity of 90-100 gpm at a 3′ head. Extremely small in size, they fit easily into the piping arrangements of the compact electrolyzers. Entirely maintenance-free with the exception of occasional bearing checks, they save "considerable time and money" at the Nangal plant.

* High-capacity, low-head Chempumps, using double-suction casings and impellers, were designed and built especially for this installation. Hydraulic balance, plus extremely low motor loading, assures uninterrupted operation for Hindustan, particularly important where maintenance is necessarily infrequent. By eliminating seals and stuffing boxes, Chempump "canned" pumps eliminate 90% of pump problems for processors throughout the world.

To learn what Chempump can do for you, write for Composite Bulletin 1100. Chempump Division, Fostoria Corporation, Buck and County Line Roads, Huntingdon Valley, Pennsylvania.

First in the field . . . process proved

CHEMPUMP®

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S. S. White Dental Mfg. Co.
General Dynamics Corp.
Nat'l. Space & Aero. Admin.
Gulf Oil Corp.
Air Reduction Co., Inc.
Allied Chemical Corp.
Aluminum Corp. of America
Atlas Powder Co.
Boeing Airplane Co.
L'Air Liquide
Baldwin Lima Hamilton Corp.
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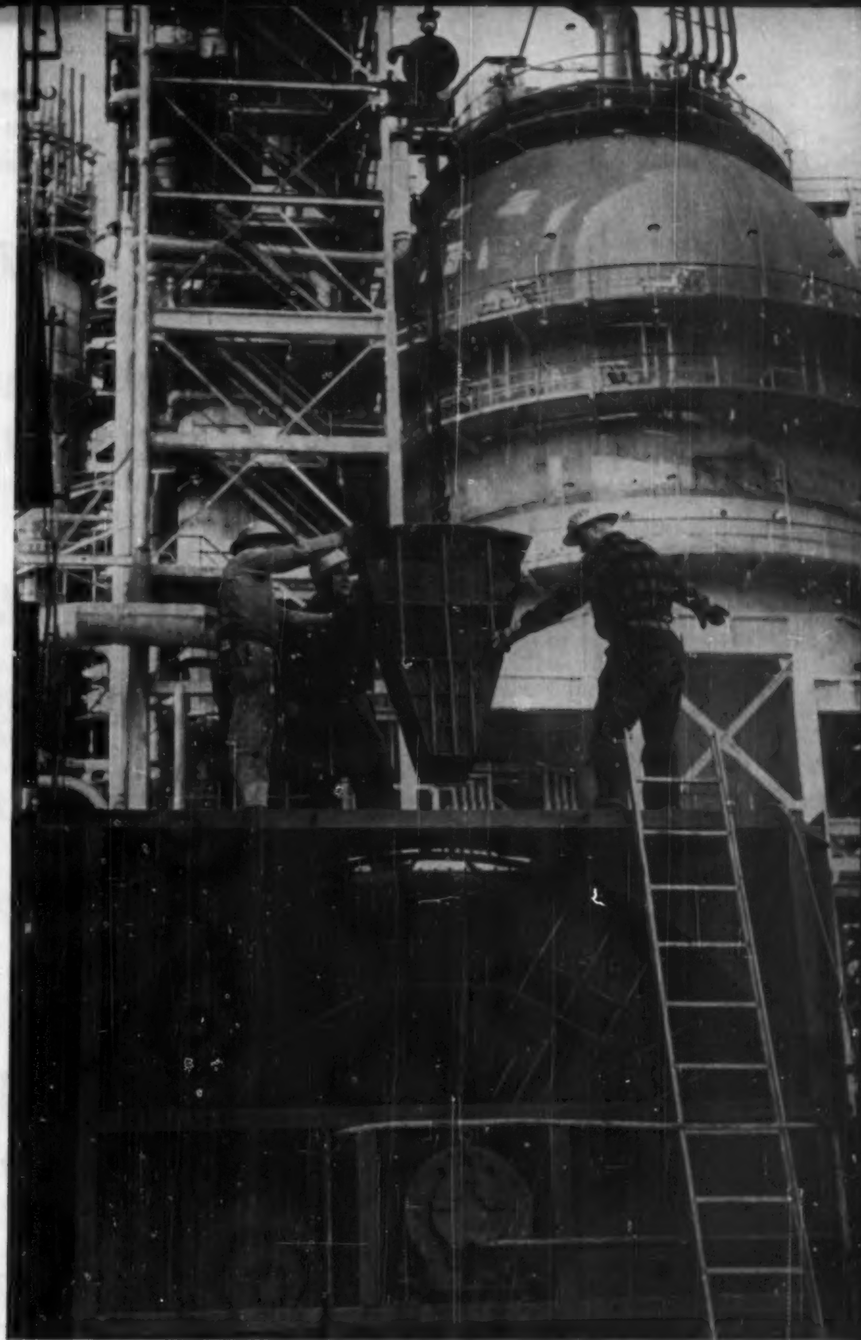
CUT FUEL BILLS 20% WITH A LJUNGSTROM® AIR PREHEATER



The world's largest fluid catalytic cracker at Esso's Bayway Refinery is equipped with a new Ljungstrom Air Preheater. This picture shows the half-ton cold-end elements being installed in the Ljungstrom rotor.

Your biggest refinery operating expense is the money you burn: fuel costs. You can chop fuel bills 1/5 with a Ljungstrom Air Preheater, and here's how:

Your fuel bill drops about 1% for every 45-50°F you raise the temperature of combustion air. Ljungstroms now in service raise the air temperature 1000°F or more – and the rest is simple arithmetic. With a Ljungstrom, four barrels of fuel do the work of five. On fuel savings alone, one eastern refinery came up with net savings of $67,800 in the first year they used a Ljungstrom.

SAME FUEL, MORE HEAT. Ljungstrom economy is flexible economy. If total throughput is more important to you than fuel savings, a Ljungstrom can help boost the capacity of a pipe still at least 10% a day, without any increase in fuel consumption.

THESE ARE FACTS backed up by 25 years of Ljungstrom performance in refineries all over the world. But they're not the only facts. To find out about Ljungstrom's low-cost maintenance, easy inspection, in-service cleanability, space-saving compactness, call or write The Air Preheater Corporation for a free copy of a brochure called "The Ljungstrom Air Preheater for Process Equipment."

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Changing post-war patent philosophy

Threat seen in growing Government ownership of patents arising from Government sponsored research and development.

"GOVERNMENT OWNERSHIP of patents resulting from government contracts poses a severe threat to the patent system as it has developed over the years," in the opinion of D. B. Keyes of the NAM. Keyes spoke on *Government's New Patent Philosophy for Contract Research*, before the recent Washington, D.C., Annual Meeting of the A.I.Ch.E.

"In the old days," pointed out Keyes, "the Government was not in the business of underwriting over 50% of all research taking place in the country, or of building plants, manufacturing articles, or generating power for sale to the public." Times have changed rapidly in the past 20 years, continued Keyes. Federal expenditures for research have increased tremendously since World War II; today the Federal Government is spending on the order of $9 billion annually, is getting into more and more areas, many of which are in direct competition with industry.

Government research and development contracts contain a clause which gives the Government ownership of any patents which may result from the contract. This is over and above the right to the free use of all inventions conceived under the contract, a right which the Government has always had. However, claims Keyes, the National Aeronautics and Space Agency, and to a lesser extent, the Atomic Energy Commission, have gone even further. On occasion, he says, these agencies demand ownership of underlying or background patents covering inventions made with private funds, separate and distinct from any government contract.

Basic patent philosophy

The important fact to remember, according to Keyes, is that the financial value of a patent to its owner, regardless of who he is, is the privilege of restricting the use of the invention to those who are willing to pay a fee for such use. This financial incentive is lost when the Government assumes ownership, for at no time in our history has our Government sued the infringer of a patent. Thus, if a patented invention is dedicated to the public, no one can sue anyone for using it. So, reasons Keyes, the only logical conclusion that can be drawn is that once a patent is owned by the Government, its financial value—to the inventor, to the Government, even to the taxpayer—becomes nil.

Cited by Keyes was a case in which, during contract negotiations for certain test work, the AEC demanded ownership of certain background patents under which the company in question receives several million dollars annually. The company refused to sign the contract, and the AEC refused to delete the offending clause. The company turned down the contract, despite the fact that it had already spent some of its own funds in getting ready to perform the tests.

"If this philosophy is allowed to continue," concluded Keyes, "this situation will develop more frequently." Even our largest industrial organizations will be unable to afford to accept government contracts under these circumstances. It will be even more serious for the smaller industrial concern whose patents may represent its greatest asset, and could mean the difference between operation and bankruptcy. "A bankrupt organization, which is no longer in business, has no value as a contractor to anyone, not even to the U.S. Government."

Wanted—New ideas in chemical engineering

A "Free Forum", to be held for the first time at the coming New Orleans National Meeting, will extend to all A.I.Ch.E. members an opportunity to air any off-beat ideas they may have been harbouring in their breasts over the years. The session will be completely on an informal basis—no formal preparation of papers, no obligation to publish, no subsequent publicity of any kind. Primary emphasis will be placed on new research ideas. However, if time permits, new ideas related to any phase of chemical engineering will be included. The meeting is scheduled for Tuesday morning, February 28, 1961, 9:A.M. to 12:00 Noon. Members are invited to submit a brief outline of the subject on which they wish to speak to M. S. Peters, Panel Moderator, Division of Chemical Engineering, Univ. of Illinois, Urbana, Ill.

Patents in research, buying foreign processes

Data and information available in patent literature invaluable asset to research program. Use of foreign processes practical, but problems must be faced South Texas members told.

PATENTS SHOULD BE USED as standard research tools. They contain important data, they contain new and useful information, and there are about 50,000 new ones issued per year. Despite the obvious, it's amazing how many technical people fail to turn to patents as a standard part of their research effort, Russell H. Schlattman, Monsanto Chemical Co., Texas City, told participants at the 15th Annual Technical Meeting of the South Texas Section of A.I.Ch.E. in Houston.

The total number of patents extant—2.9 million have been issued, 2.3 million have expired—should not be a deterrent in themselves, he stated. The U.S. Patent Office provides numerous services and is well-equipped to furnish documents covering specific areas, thereby automatically limiting the total search.

The difficulty in keeping trade secrets—especially on such things as catalyst types—means that patent protection is being sought more and more in the chemical field, and as a result more and more information thereby becomes available.

Contrary to a prevailing opinion, patents are not primarily issued to protect the inventor. According to the constitution the patent system was set up in order to promote the arts and sciences. The protection to the inventor is a means to this end, for the patent system says to the inventor that if he will disclose in writing his information, they will exclude everyone for 17 years. Meanwhile, the information can be used to develop other inventions. Hence, the data and details are there for the asking, he said.

A researcher can take advantage of the patent by digging into the patent, and he can expedite his study by concentrating on a few prime sections. Most patents are written with an introduction to the state of the art. This is a section which can be scanned. The researcher can concentrate on the specific examples and the statement of the invention. These contain the meat of the patent says Schlattman. This information can be used in research work. Any good research organization should have a patent library on its own subject area. It is one of the cheapest libraries you can build said Schlattman, since a twenty-five cent piece buys a copy of any patent around.

Importing a process

Many factors have caused companies to buy processes overseas, and peculiar problems have grown out of these developments, R. E. Lenz, Monsanto, St. Louis, said at the meeting. Initially, there is the problem of finding out about the processes. With established products, there are published lists available. With respect to upcoming developments, it is advisable to have technical people abroad to do technical scouting. It is also wise to conduct patent searches, and the Belgian patent office is one of the best to work through. Patents are issued at a very fast rate by this organization, Lenz said.

Once a process has been found desirable, it has to be evaluated for U.S. conditions. This can be most difficult, Lenz said, since it is almost impossible to make direct comparisons based on European data. In many cases it is necessary to make a formal agreement before a company will release enough data for a decent estimate to be made. In order to protect both parties, it is best to negotiate a two-step agreement. In the first phase preliminary data is made available. If the second step option is taken up full disclosure is then made at a price already agreed upon. There is still an aspect of horse-trading involved in making process agreements. If the price isn't set in advance, a company's interest in taking the second step could easily cause the price to jump.

Even with access to data, the problems still remain. Usually the data applies only to specific conditions and cannot be taken at face value. For instance, there may not be kinetics data available except at the one temperature at which the process has been operated, or yield data may be available only for rigid and limited operating conditions. In some cases, considerable research may be required on the part of the purchaser to get information applicable to operating conditions in the U.S. Finally, tight time schedules should be treated with extreme care, Lenz said. Translation problems alone require an enormous amount of excess time despite modern communications.

The increased number and variety of processes available abroad, the continuing sharp competition within the industry, and the opportunities to be had, mean that use of foreign processes will continue despite the problems, Lenz stated.

Anatomy of a profession

A ratiocination: the engineer's training makes him eminently suited for wider emergence into public life as well as the manipulation of nature.

"OUR NATION NEEDS THE MAN with the cultivated mind and the broad outlook—with vision and capacity for independent thinking—who *pursues* ideas—who *seeks* to solve problems—a man whose thought processes do not end at the close of the business day. Who but an engineer fits these requirements?". . Such was the preamble of J. F. Dudley, V. P. of Production and Engineering for Commercial Solvents Corp., in exhorting members of New York's local A.I.Ch.E. section to more active participation in public life.

"Activity in politics at the local level," Dudley continued, "might well prove worthwhile for chemists and chemical engineers. Attendance at a precinct caucus would be highly educational in the ways of people. It could help dispel the widespread idea among non-scientists that scientific 'eggheads' are a totally different breed.

"In too many instances the engineer lacks the dynamic conviction of his own importance and value as a citizen, and by adhering too closely to his own specialty in a greater or lesser degree, he neglects his duty as a citizen. The results of such apathy for any group are always bad. For the engineer, with his unique status, they are worse," he cautioned, and went on to say, "One of the major activities in which an engineer can participate is education. Who better than an engineer can serve on curriculum committees, and the like, in these days when science studies are all important?

"The engineer, working in close liaison with the pure scientist, must necessarily play a most important, perhaps a dominant, role in making the decisions and determining the management pattern of the future national program. The necessary background for such a responsibility will involve much more than a compilation of facts, familiarity with handbooks, facility with the slide rule, or expertness with computers."

In the same "Anatomy of a Profession" symposium, A. J. St. Louis, Training Director of Food Machinery & Chemical's Chemical Division, put forth some guides he uses to *Engineer the Engineer's Future*. "Don't oversell the company during job recruitment! The introduction of new personnel should be a planned program—as should on-the-job training. But they should be tightly planned, not drawn out.

"Promotion," he continued, "should be based on evaluation of job performance rather than personality. In the same vein, advancement opportunity should be based on a strong policy of promotion from within, not necessarily restricted to vertical promotion. Lateral promotion is also possible."

In short, he recommended the same principles to govern investment in engineers that would apply to capital investments, namely: 1) adequate search, 2) proper installation, 3) intelligent trial or break-in, 4) thorough followup.

Contrasting the chemical engineers' lot in the U.S. and Europe, J. G. Devys, Chairman of Etude et Realisation de Projets Industriels, provided some clues to the disparate rates of development here and abroad.

The basic difference in chemical engineering philosophy between Americans and their (western) European counterparts is explained by the fact that although the greater body of chemical engineering knowledge originated in Europe, none of the innovators described themselves as chemical engineers. Reasons for this lack of identification probably are linked with the more theoretical and less pragmatical scientific teaching in Europe. The products of such teaching (chemists, physicists, mechanical engineers) find themselves fulfilling, with apparent success, all the functions to which chemical engineers lay claim.

A notable point of difference in European students is that the idea of working one's way through college, common in America, is almost nonexistent. Students completing a degree course are technically further advanced than their American counterparts.

There is an even greater difference in status. Terms such as "egghead" or "longhair", with their unfavorable connotations, are almost unknown. To the Dutch, Germans, and Swedes "Engineer" is as honorable a title as "Doctor" or "Reverend".

The average European "chemical engineer" in industry probably earns about $5600/yr. compared to an average $10,436 in U.S., but the former is better off because fringes such as expense accounts, automobiles provided and maintained by the company, and a hundred other advantages make the lot of the European chemical engineer more pleasant than might appear from a consideration of straight salaries.

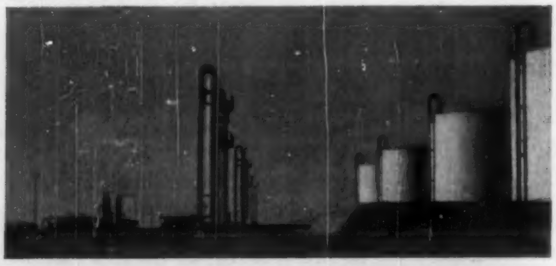
In his *Ratiocination*, Shell's Industrial Chemical Division Manager A. W. Fleer wove a delicate web describing the origin and growth of chemical engineering, using the study and knowledge of physical and natural sciences as a basis of understanding nature and its possible manipulations. Fleer summed up the whole subject with, ". . . we find the chemical engineer well adapted by training in sciences and engineering arts, and with broad attitudes of acceptability of and integration of new knowledge, with a big dash of the humanities, well fitted to cope with the highest challenges of our day."

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

NEW PROCESSING PLANT AT HASSI-MESSAOUD STABILIZES 150,000 B/SD OF LIGHT CRUDE

The S. N. REPAL permanent field processing plant at Hassi-Messaoud, Algeria, is now operating at its capacity of 150,000 barrels per stream day of stabilized crude oil. The installation gathers, degasses, stores and transports a very light crude (0.8 sp. gr.) produced at the four-year-old Hassi-Messaoud field and destined for the Haoud El Hamra-Bougie pipeline to the Mediterranean. It was built by Societe Francaise des Techniques Lummus in this remote location, under extreme climatic conditions, in less than nine months from the time materials began to arrive at the site—and was completed ahead of schedule.

General view of the Hassi-Messaoud plant, showing vertical, third stage separators (center), part of horizontal separators, and four intermediate storage tanks.



Rear view of control house with its specially-designed roof for Saharan climatic conditions.

In May, 1958, Societe Francaise des Techniques Lummus was assigned the task of planning, engineering and constructing the plant, the primary purpose of which is to remove the very large quantities of natural gas associated with the Hassi-Messaoud crude (gas: oil ratio by volume is about 200:1). A temporary installation handling limited crude capacity existed at the site when the Lummus company was called in.

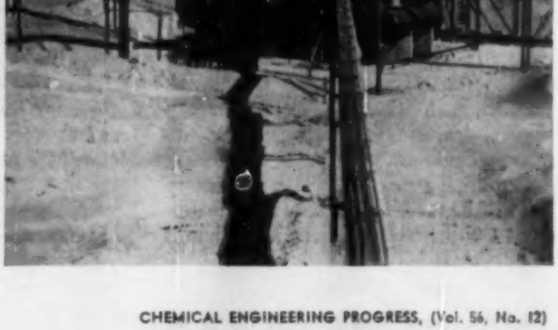
By September, 1958, plans were completed and purchasing began. Almost all the materials were bought in France or Algeria. However, electronic control apparatus was obtained in the United States. Over 4,000 tons of material were transported across the Mediterranean Sea, the Atlas Mountains, and the desert to arrive at a rocky plateau rising about 100 feet above the old dry valley of Oued Irara.

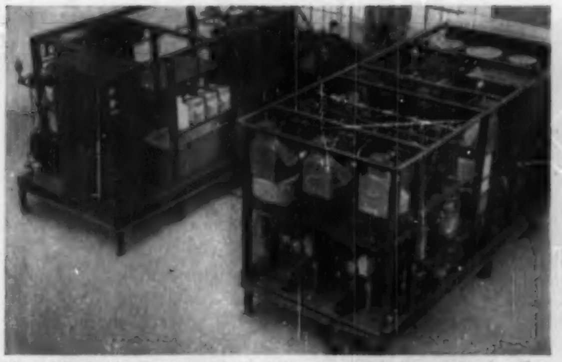
In addition to transportation difficulties, Societe Francaise des Techniques Lummus had these handicaps to overcome during construction proper, which got underway in January, 1959: a water table lying 150 feet deep, which posed problems in electrical grounding of equipment; conducting the major part of the work during the hottest months, with temperatures ranging from 104-130°F.; violent sand and dust storms, characteristic of the area.

In spite of the problems, on September 24, 1959 —ahead of schedule—the gas separators were put into operation and the flares lit. The first shipments through a 16-inch pipeline to Haoud El Hamra Terminal, 19 miles away, began shortly thereafter.

SFTL is one of the seven International Groups of Lummus companies which circle the globe to serve the process industries wherever plant design, engineering and construction are needed.

The condensate drums and control station with the high and low pressure flares.





Two skids hold complete nitrous oxide plant ready to move to location in "flying boxcar."

Portable Nitrous Oxide Generator Being Constructed for U. S. Army Engineers

Design, construction and testing of a portable nitrous oxide generator for the U.S. Army Corps of Engineers is being carried out by The Lummus Company at its Engineering Development Center, Newark, N. J.

The plant will afford a field supply of 40 lb. per hr. of liquid anesthesia for use under combat conditions, at a cost of about $250,000 per generator. The process, specified by the Army, is conventional decomposition of ammonium nitrate by heat. Ammonium nitrate can be shipped in bags, eliminating the return of empty anesthesia cylinders which presently causes problems.

Dimensions of the unit were dictated by the size of the rear door of a "flying boxcar". As designed, the plant is mounted on two skids, eight feet square by 20 feet long. It has shock and thrust resistance for portability by plane, train or truck. It is simple enough for operation by soldiers getting instruction from a manual.

The nitrous oxide product meets USP purity requirements.

The equipment in the unit includes:

On the first skid

Ammonium nitrate melting pots of aluminum.

Decomposition vessels of aluminum.

Caustic, sulfuric acid and steel wool scrubbers made of glass-fiber-reinforced polyester resin. Packings for the caustic and acid scrubbers are polyethylene Tellerettes.

On the second skid

Compressor of a type that compresses gas by flexing a diaphragm with hydraulic fluid.

Hot KOH absorber.

Desiccator.

Liquefier – a 1¼-ton fluorinated hydrocarbon refrigeration unit.

Stripper.

Bridging the two skids

A plastic gas-surge bag of 300 cu. ft. capacity which weighs only 30 pounds and folds up into a small bundle for storage. It consists of an inner envelope of vinyl plastic sheeting and an outer casing of vinyl-impregnated nylon fabric. It was specially designed for this portable plant.

Because parameters set by the Army pose many problems in selection of materials of construction, selection and positioning of equipment and instrumentation, Lummus' Engineering Development Center will provide the Army with an R&D prototype unit which may save them a great deal of expense and inconvenience.

FMC selects Lummus as principal sub-contractor on new Army Chemical Corps Contract

A new Army contract for a Chemical Corps production facility near Newport, Indiana, in excess of $13,000,000, has been awarded to the Food Machinery & Chemical Corporation. The contract calls for the design, construction and test operation of a plant to produce classified material. The Lummus Company has been selected as principal sub-contractor to design, construct and assist in test operation. Food Machinery & Chemical Corporation have the responsibility for operating this government-owned contractor-operated facility for some period to follow.

book reviews

ANALYSIS OF STRAIGHT-LINE DATA, Forman S. Acton, Associate Professor of Electrical Engineering, Princeton University, John Wiley and Sons, Inc., New York, N. Y. (1959), 267 pages, $9.00

This is an excellent example of a type of book needed more and more in this era of specialization. The book itself is a detailed treatment of restricted subject that is common to other fields of specialization—in fact to all fields that deal with the real world by means of the scientific method. It should be a useful book to all engineers, and has a particular appeal to chemical engineers because of the many examples given in their language.

Acton points out in more than one place that the straight line is of special interest to the engineer. In fact, if data does not fit a straight line naturally it is liable to have one thrust upon it. In one pithy comment to this effect he says "Although it is far from certain that our Creator cast this univerrse in a linear mold, it is quite certain that we strive continually to force it back into one."

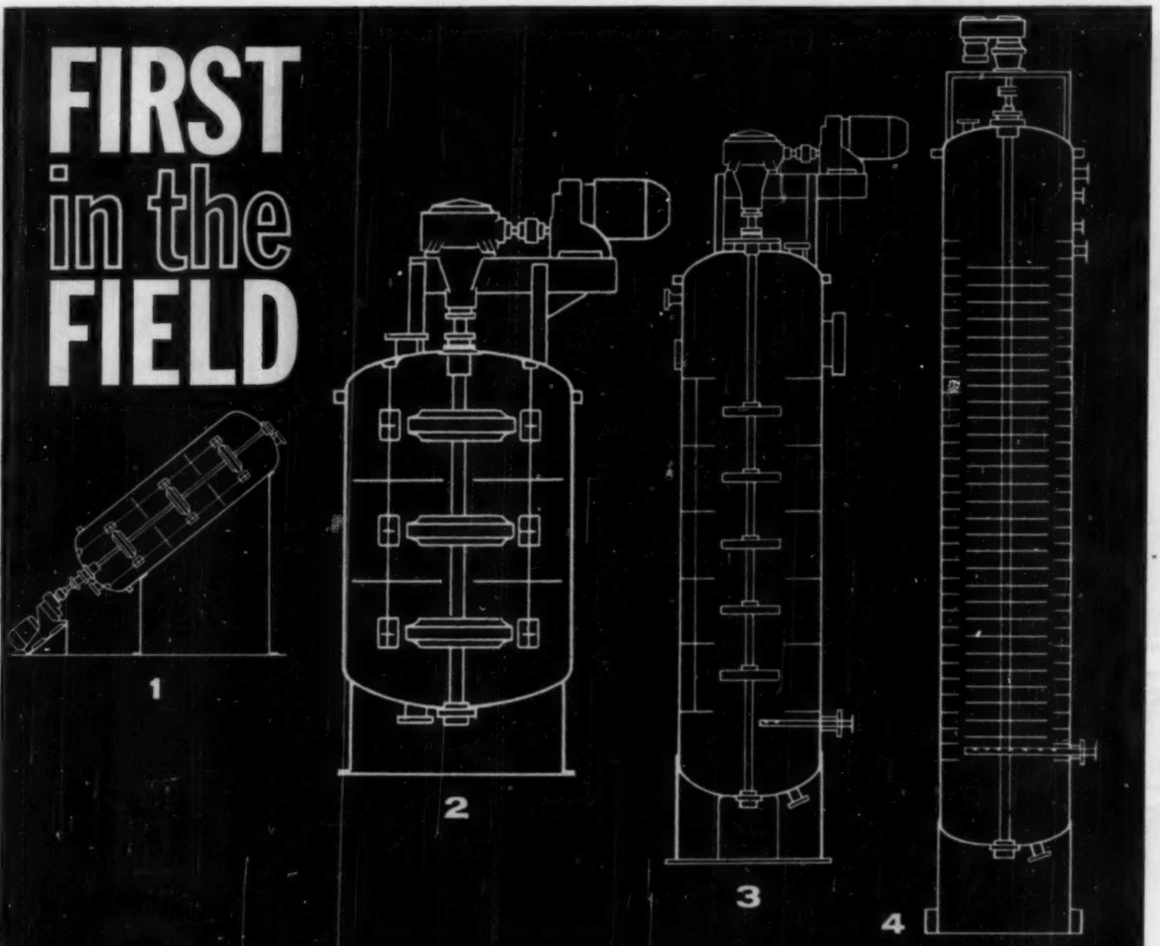
In his first chapter on the choice of a model, Acton makes it clear that the use of the classical least-squares procedure is limited in application by the nature of errors normally encountered in practice. He makes a substantial plea to the experimenter to design his experiment to answer the important questions. To do this the experimenter should consult his statistical knowledge (or his statistician) before setting up the experiment, not after the data are in hand.

The chapter on the rejection of unwanted data is actually a strong plea to the engineer to not be quite so hasty in "throwing the rascals out" as they normally tend to be. Methods of rejection are considered, but Acton's warnings are well worth the attention of all engineers.

This book can be useful to all chemical engineers who deal with experimental (i.e., real world) data. To make full use of the book requires a background in mathematical statistics, but any graduate engineer should be able to use parts of it. For those willing to invest the time and effort this book has much to offer. It is to be hoped that many will be interested enough to make the effort.

Reviewed by Frank P. May, Department of Chemical Engineering, University of Florida, Gainesville, Florida

For more information, circle No. 65



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For more information, turn to Data Service card, circle No. 28

letters to the editor

Correcting the record

To the editor:

I have read the write-up on the panel discussion at the Tulsa meeting (Scope, Nov.), and it reads well. It has one slight error in that it states that one of Miller's responsibilities was "being in charge of an electric furnace plant for the manufacture of elemental phosphorus." Miller was never in charge of a manufacturing plant; he was in charge of the construction of one.

J. J. Healy, Jr.
Monsanto Chemical Co.
St. Louis, Mo.

We didn't like your photograph

To the editor:

I have just read Mr. E. H. McKinney's article "Radiation Techniques for Process Measurement" and would like to compliment both the author and editor for making available one of the finest technical discussions on the application of nuclear gaging techniques in the chemical industry. Mr. McKinney's article is an exceptional piece of technical writing and a major contribution, not only to the chemical industry, but to the processing industry in general. His discussion is extremely thorough yet clearly readable and understandable. Nowhere, in my knowledge, is so much information contained in a single article describing radiation techniques for process measurement.

I can find what I believe to be only one legitimate criticism with the article and this is not the author's doing. It is in the choice of the photograph shown on the first page of the article. In contrast to the article, the photograph presented lacks accuracy and realism because the application is one unrelated to the chemical processing industry. Whereas, the whole of Mr. McKinney's discussion deals with nuclear gaging in chemical processing plants and his experience gained from working with nuclear gages, the photograph shown refers to a simple type of level switch operating in a steam generation plant. To be more precise, the picture shows a radiation level switch on a coal hopper located at the Conesville Generating Station, Columbus and Southern Ohio Electric Company.

If you will review Mr. McKinney's article, you will find that this is not the type of radiation detector that he refers to in many of his calculations as well as data curves. Also, the use of equipment shown in the photograph is extremely limited in chemical processing plants and I doubt whether more than 10% of the nuclear gages are this type.

You would have been doing a far greater service to your readers had you shown a photograph of a typical installation in a chemical processing plant and more in keeping with Mr. McKinney's discussion.

It may be that the editor felt that for purposes of atmosphere and color, the picture chosen might have had a more dramatic effect, however, it is my feeling that the purpose of a magazine such as *Chemical Engineering Progress* and other society publications is not one of presenting atmosphere, but plain facts.

Maybe one of the reasons that I feel so strongly about this matter is because to me the picture appears to give the impression that the manufacturer of the product shown in the pic-

continued on page 30

For more information, turn to Data Service card, circle No. 58

ADVERTISEMENT—*This entire page is a paid advertisement* *Prepared by U. S. Industrial Chemicals Co.*

U.S.I. CHEMICAL NEWS

December ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1960

Polyethylene Coatings Cut Fertilizer Loss in Soil

It has been reported recently that coating conventional fertilizers with polyethylene slows down the rate at which they release constituents to the soil. In experiments, a coated fertilizer lost only 5.4% of its potassium, while uncoated fertilizer lost 81.3% in the same period.

Most fertilizer salts dissolve very rapidly in most soils, and, if not used, can be lost. Fertilizer is generally applied when a crop is planted or starts growing, when its nutrient needs are small, and not at midseason, when the nutrients are most needed by the crop. It is felt that by coating the fertilizer, and metering out the nutrients more nearly as plants require them, a more efficient use of fertilizer would result.

New Denaturant Approved For SDA-40 Formulations

The Alcohol & Tobacco Tax Division has just approved a third denaturant for use in specially denatured alcohol (Formula No. 40) — a synthetic organic called "Bitrex," chemically, benzyldiethyl (2:6-xylylcarbamoyl methyl) ammonium benzoate.

"Bitrex" is much more bitter than brucine or quassin, the two denaturants used exclusively in SDA-40 until now. In addition to ⅛ gal. tert-butyl alcohol, only ¼ oz. of "Bitrex" is required to denature 100 gallons of ethyl alcohol, as against 1½ oz. for the other denaturants.

There are now four SDA-40 formulations approved by ATTD. U.S.I. designations are as follows:

SD-40-1 . .	1½ oz. brucine alkaloid
SD-40-2 . .	1½ oz. brucine sulfate
SD-40-3 . .	1½ oz. quassin
SD-40-4 . .	¼ oz. "Bitrex"

Cl_2-N_2 Mix Suggested for Degassing Aluminum Melts

A new treatment has been proposed for removing dissolved hydrogen and included oxides from molten aluminum. It employs a mix of 10% chlorine—90% nitrogen.

In melting and casting aluminum, oxides must be eliminated and hydrogen controlled. Chlorine treatment is regularly used but, in an attempt to eliminate fuming and corrosion problems, nitrogen has been tried. However, results from nitrogen flushing vary from day to day.

Experimenters have determined that 10% chlorine and 90% nitrogen gives the consistent results of chlorine alone, releases no fumes, eliminates corrosion.

U.S.I. Expands Program to Give Handling Help to Sodium Users

New Hydrocarbon Desulfurization Process, Other New Uses Spur Interest in Sodium Equipment, Maintenance, Safety

Because of the interest in new uses of sodium such as U.S.I.'s new, economical sodium process for reducing thiophene levels in hydrocarbons, the company expects increased interest in its program of plant design assistance to sodium users. U.S.I.'s sodium production engineers have often helped customers and prospects set up and maintain trouble-free operation in plants using sodium. The company now plans to make more plant men available to work on these problems.

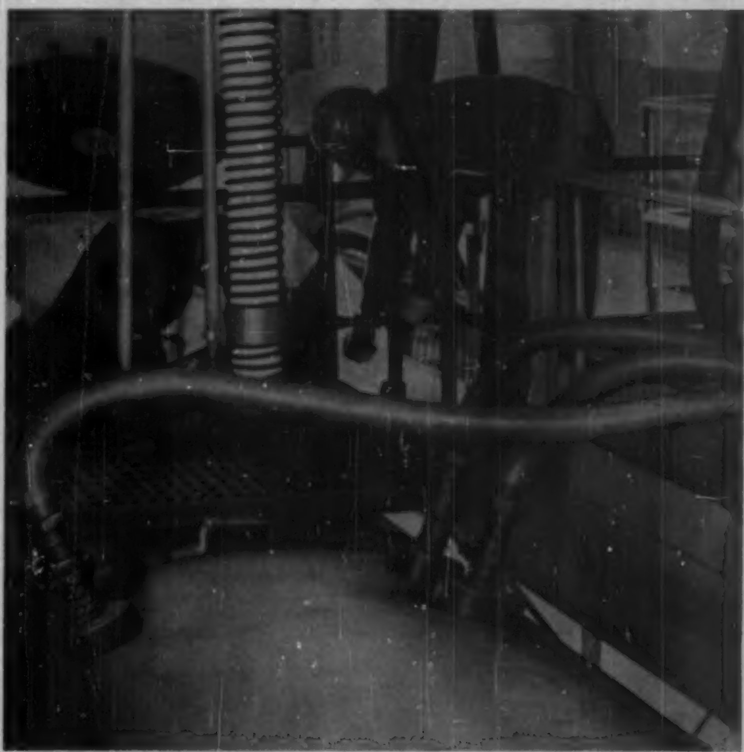
Layout and Equipment Assistance

Engineers from U.S.I.'s Ashtabula, Ohio, sodium plant can and do provide engineering help in laying out sodium processing and handling equipment. Typical examples are tankcar unloading stations, solid pack melting layouts, design and layout information on sodium lines, filters, pumps, valves and metering.

MORE

New Caustic Soda Book Just Issued by U.S.I.

Facts about caustic soda are covered in a new, 36-page booklet now offered by U.S.I. Up-to-date, practical information on properties, applications, methods of analysis, shipping, handling procedures, and safety measures is included. There are many graphs and tables, an extensive bibliography, and a complete index. For your copy, address Technical Literature Dept., U.S.I. Chemical News, 99 Park Ave., N. Y. 16, N. Y.



In typical sodium tankcar unloading station, designed by U.S.I. plant engineers, molten sodium discharges through vertical pipe heated by induction coil. Hot oil flows into tankcar coils through metal hoses.

December ★ **U.S.I. CHEMICAL NEWS** ★ 1960

CONTINUED

Sodium Handling

The Ashtabula men, from their own production experience, have the specialized knowledge required for selecting proper types of pipe, valves, flanges, gasketing materials, line heating devices, and other accessories. On many occasions, they have been able to give a customer the maximum of troublefree operation by sharing this experience with them.

In addition to offering initial plant design assistance, U.S.I. engineers will trouble-shoot existing sodium handling equipment, and can usually make recommendations that will enable customers to correct troublesome situations at minimum expense.

Safety and Maintenance Instruction

In many instances, safety instructions are needed by customers. The information which U.S.I. plant men have supplied on the safe handling of sodium, and disposal of scrap, to customers' safety engineers and operating personnel has proved very helpful. This has done much to allay the fears some people seem to have in handling sodium.

One of the most common aids to customers is instruction in the cleaning of sodium drums, valves, fittings, pipe lines and filters. Very simple procedures are involved, but they must be seen at first hand to minimize problems.

Customers often require assistance in the repair of sodium valves and other process accessories involved in the handling of sodium. Here again U.S.I. plant men are able to make recommendations and supply definite information and specifications.

U.S.I. also makes available a comprehensive brochure, "Handling Metallic Sodium on a Plant Scale," to help customers and prospects with processes involving the metal. The company recommends that this brochure be studied first, after which the U.S.I. sodium plant engineers can be consulted on handling problems.

Role of Patent Department In Chemical Research Stressed at ACS Symposium

In a "Planning for Research" Symposium held by the ACS Division of Chemical Marketing and Economics on Sept. 13, Dr. Janet Berry, Manager of U.S.I.'s Patent Department, discussed how close cooperation between Research and Patent Groups can assure best results from a company's research and development program.

In the initial planning stage of a project, Dr. Berry pointed out, a Patent Department *informed of the plan* can search patents and literature thoroughly to acquaint research management with all of the prior art. This prevents costly duplication of work, and provides a complete foundation on which the research group can build. The savings in time and money can be enormous.

In the active laboratory stage, Dr. Berry emphasized, Research can not always know just what should be patented. If complete reports on *all* developments are sent to the patent group for evaluation during this stage, the patents applied for can be of greatest value to the company.

In the final commercialization stage, Dr. Berry concluded, further benefits can be obtained by reporting all design or process changes during scale-up to the Patent Department. These changes can then be examined for further important innovations which may be patentable.

Dr. Berry

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

New anti-static spray suggested for use during printing and converting of plastics, paper, textiles; during chemical processing; on instruments, etc. Said to chemically neutralize static generated from atmosphere or friction. **No. 1660**

Infrared spectrophotometers, gas chromatography instruments and accessories now being leased to users on three-year basis, after which users may renew lease or buy instruments at small percentage of original cost. **No. 1661**

Fertilizer-grade ammonium nitrate is subject of new manual now available at nominal cost. Covers recommended procedures for proper packaging, handling, transportation, storage—at all stages from manufacturer to consumer. **No. 1662**

Advantages of bulk handling of polyethylene resins discussed in new, 24-page booklet. Analyzes in detail—with help of photos, diagrams, charts and tables—economics of bulk handling in differing situations. **No. 1663**

Titanium welding is subject of new booklet now being sold. Discusses best methods for welding piping and tubing by gas tungsten-arc process. Information has been gathered from laboratories, companies, colleges and literature. **No. 1664**

Synthetic magesium silicate covered in new data sheet. Said to be efficient purifying agent for contact filtration refining of organics such as alcohols, aldehydes, esters, ethers, halogenated hydrocarbons, monomers, silicones, syrups, solvents. **No. 1665**

Self-emulsifiable sperm oil, recently developed is said to give permanent emulsions by agitating 5-10% of product with 95-90% hot or cold water. Offered for cutting oils, textile and leather oils, petroleum additives, etc. **No. 1666**

"Properties and structure of polymers" a new book now being sold. Explains important features of mechanical behavior of polymers in terms of fundamental principles of molecular behavior and structure. **No. 1637**

New phosphating cleaner and metal conditioner reported to remove rust, corrosion, mill-oil in one step; to retard corrosion and oxidation; to deposit new type colorless phosphate coating on surfaces. Very good rinsability claimed. **No. 1668**

New high-melting synthetic wax (M.P. 156°C, 313°F) commercially available. Is hard brown wax with very high flash point and good electrical insulating properties. Insoluble in all solvents at ordinary temperatures. **No. 1669**

PRODUCTS OF U.S.I.

Heavy Chemicals: Metallic Sodium, Anhydrous Ammonia, Ammonium Nitrate, Nitric Acid, Nitrogen Fertilizer Solutions, Phosphatic Fertilizer Solution, Sulfuric Acid, Caustic Soda, Chlorine, Sodium Peroxide.

Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fusel Oil, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOL®, Diethyl Oxalate, Ethyl Ether, Acetone, Acetoacetanilide, Acetoacet-Ortho-Chloranilide, Acetoacet-Ortho-Toluidide, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate, Urethan U.S.P. (Ethyl Carbamate), Riboflavin U.S.P.

Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Urethan USP, Intermediates.

Ethyl Alcohol: Pure and all denatured formulas; Anhydrous and Regular Proprietary Denatured Alcohol Solvents SOLOX®, FILMEX®, ANSOL®M, ANSOL PR.

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Animal Feed Products: DL-Methionine, MOREA® Premix (to authorized mixer-distributors).

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letters to the editor

from page 24

ture is the one that has supplied the Du Pont Company with the majority of its equipment. In order to correct this impression, I should like to point out that an overwhelming percentage of nuclear gages in use by the Du Pont Company are of Ohmart design and manufacture.

Earl M. Pollock
Vice-president
Ohmart Corp.
Cincinatti

We sent it and we liked it

To the editor:

Thank you very much for your letter of September 19th, 1960, and, also, the copy of "Radiation Techniques for Process Measurements" by Mr. Alfred H. McKinney of E. I. Du Pont. You will recall that you used a photograph I sent you in the article. This appeared in the September Issue of *Chemical Engineering Progress.*

We thought the article was extremely well done, and would like very much to obtain approximately 125 to 150 copies of this report on radiation techniques in its entirety. These would be used for distribution to our field personnel.

Paul M. Werth
Director of Public Relations
Industrial Nucleonics Corp.

Write your Congressman

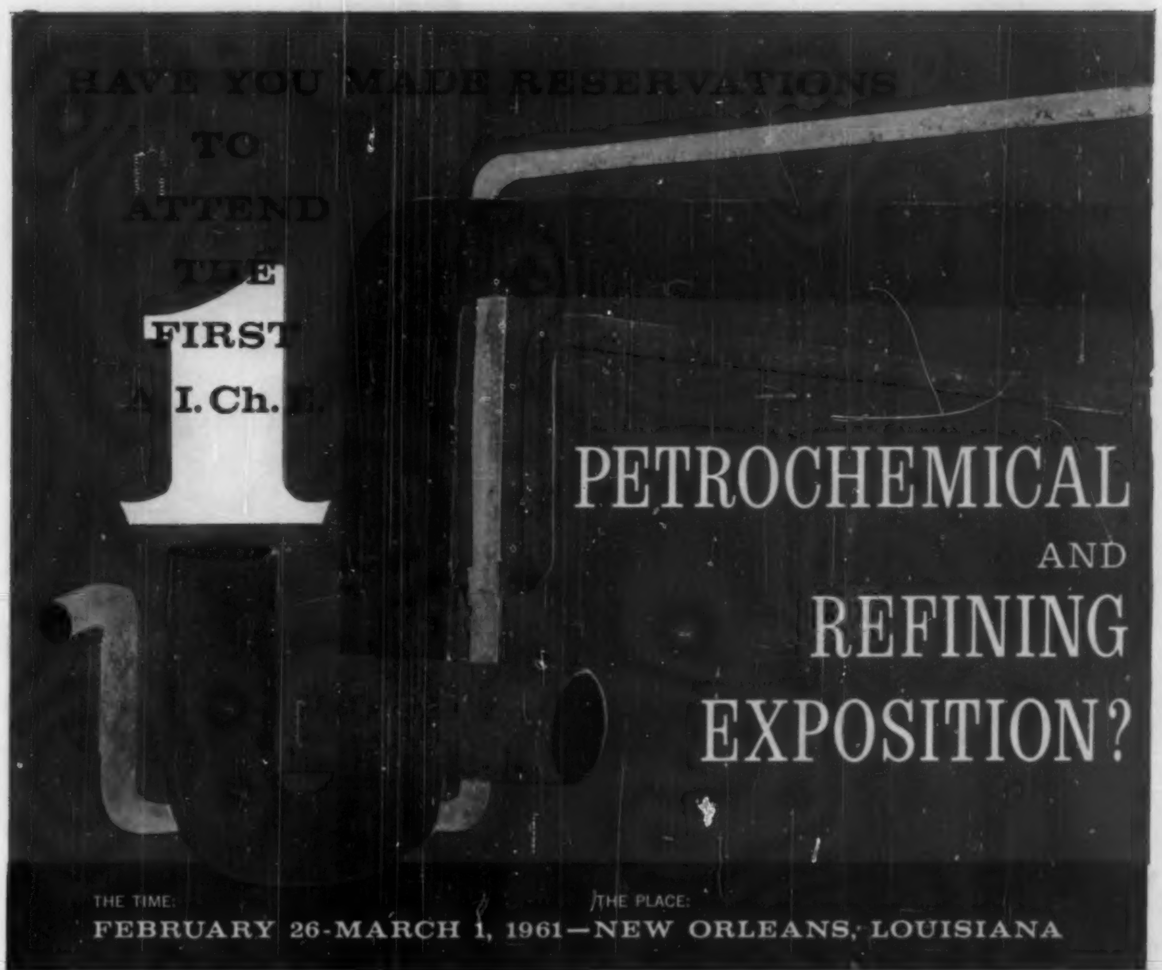
To the Editor:

Your idea of news letters is excellent. It certainly gives a more personal touch that the same news in the formal publications does not.

If you are open for suggestions on what may be appropriate topics for discussion, let me suggest that you promote the writing of letters to Congressmen. One field the busy engineer is most apt to shy away from is politics. We must advise the elected representatives of our desires and ideas. I doubt if many engineers are sounded out on these ideas by the politician.

Guy Borden, Jr.
Black, Sivalls & Bryson, Inc.
Cincinnati

This letter was written to A.I.Ch.E. prexy, Jerry McAfee, who, as you know, is mailing several newsletters this year to each member. Reader Borden will be interested in knowing that a pamphlet on "Citizen's Responsibilities" is under preparation by an Engineer's Council for Professional Development committee.—Ed.



It's the hottest news in the industry today—the first annual Petrochemical and Refining Exposition, sponsored by the American Institute of Chemical Engineers. More than half the space for the exhibits has already been reserved, and hundreds of industry leaders have made reservations to attend all the meetings, as well as the exhibition itself.

Have you made your plans yet?

If you haven't, better hurry, for this exposition is bound to be one of the most interesting you will ever attend. Sparked by the latest developments in the country's most rapidly expanding industry, the meetings and exhibits will take you behind the scenes of today-and-tomorrow in petrochemicals and refining, and will present a bird's-eye picture of what's-new-and-why.

PLAN YOUR TRIP TODAY!

Hotel space is certain to be at a premium for this unusual show, so we suggest an early reservation. Contact the American Institute of Chemical Engineers, 25 West 45th Street, New York 36, N. Y. for details and further information.

For complete and up-to-date information on on the latest petrochemical developments, you should become a member of the American Institute of Chemical Engineers. Just send in this coupon for full information.

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25 West 45th Street, New York 36, N. Y.
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Please send me full information about the benefits of membership in the American Institute of Chemical Engineers.

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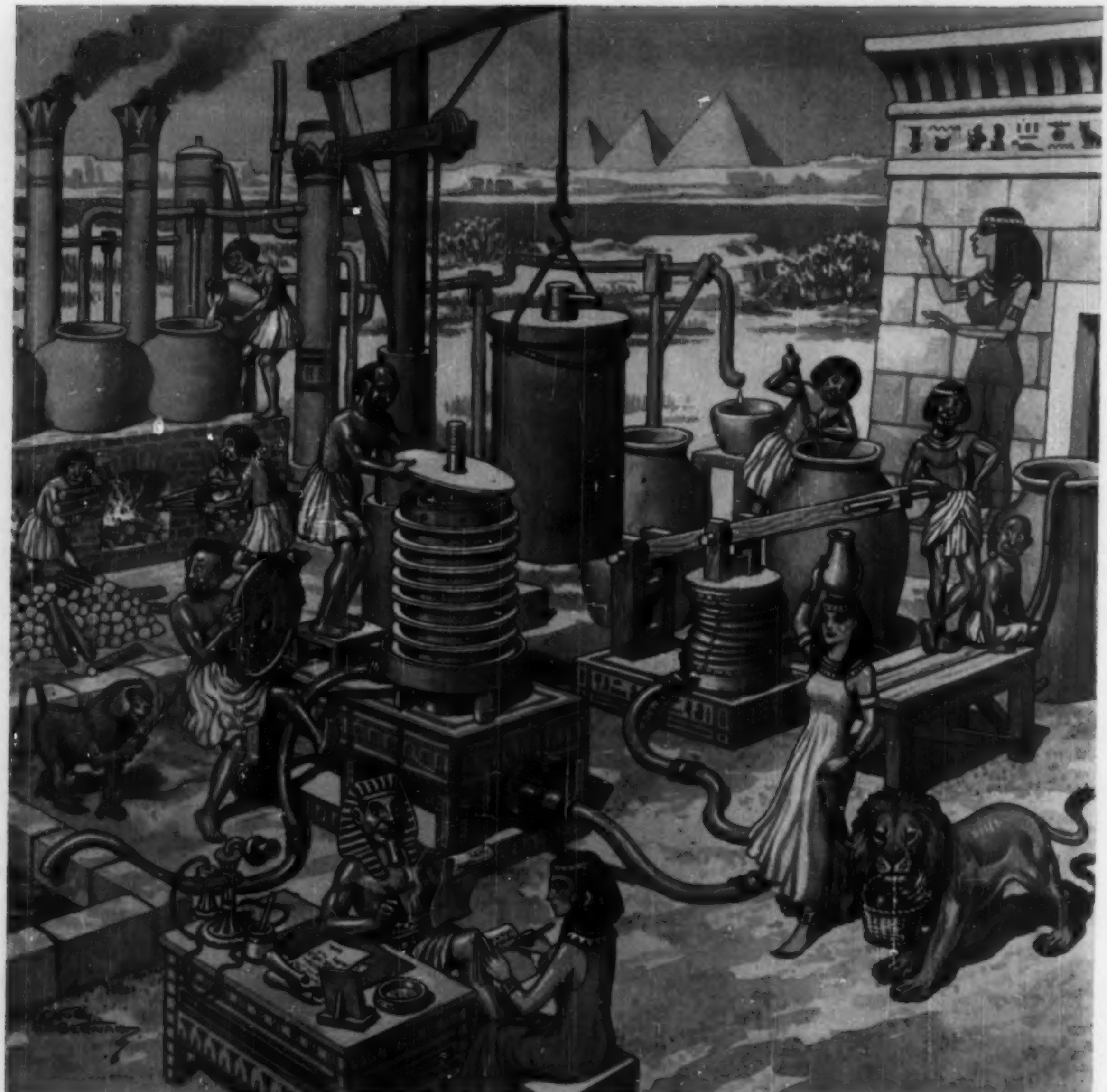


CEP . . . . .trends

Foreign competition seen no menace to U. S.

Two DIAMETRICALLY OPPOSED trends are apparent today in the chemical industry of the non-Communist World. The first, integrating, centripetal, seems to be at work in the United States, Western Europe, and in certain other non-European but technically advanced countries such as Japan and Australia. The second, disintegrating, centrifugal, is evident in most of the so-called "under-developed" nations—India, Indonesia, a large part of South and Central America, most of Africa.

What, in particular, is the threat to the U. S. chemical industry of the booming expansion of Western Europe in the chemical field? Probably not too serious, according to executives of one of the largest American chemical companies, itself deeply involved in international operations.

Labor a small factor

Rates for direct operating labor in Western Europe average at least three times less than those prevailing in the U. S. Productivity of the average European worker in the chemical industry is estimated at about 75% of that of his U. S. counterpart. This would, on the face of it, seem to lay the United States open to large-scale invasion of its domestic chemical markets by European producers, in spite of tariff protection.

However, in the opinion of U. S. chemical company executives, the situation is by no means as desperate as it might seem. In the first place, the labor factor involved in most large-scale chemical manufacturing is fairly low, probably not averaging over 20%. In addition, increasing automation promises to lower the labor factor still further. Conclusion—not labor rates, but raw material costs will everywhere be increasingly determining for total manufacturing costs.

Direct labor costs, furthermore, are not the whole story. For a European company, for instance, to invade the U. S. market in a big way, it will have to set up market research and sales staffs in the United States comparable to those maintained by the American companies themselves. At this point, the hopeful European competitor will be letting himself in for large overhead outlays, based on U. S. wages and costs, inevitably cutting down any inherent competitive margin based on lower manufacturing wage rates outside the United States.

Basic trend, therefore, for the forseeable future at least, is for the gradual leveling out of prices, wage scales, and probably of the overall standard of living between the U. S. and Western Europe. The gap, in spite of what would seem to be considerable wage differentials, seems to be closing rapidly; in fact, wages themselves are increasing in Western Europe at a rate of about 8% per year, as against about 5% in the U. S. This leveling trend can only be accentuated by activities such as that of GATT (General Agreement on Tariffs and Trade), and by such integrating movements as the European Economic Community and the European Free Trade Association.

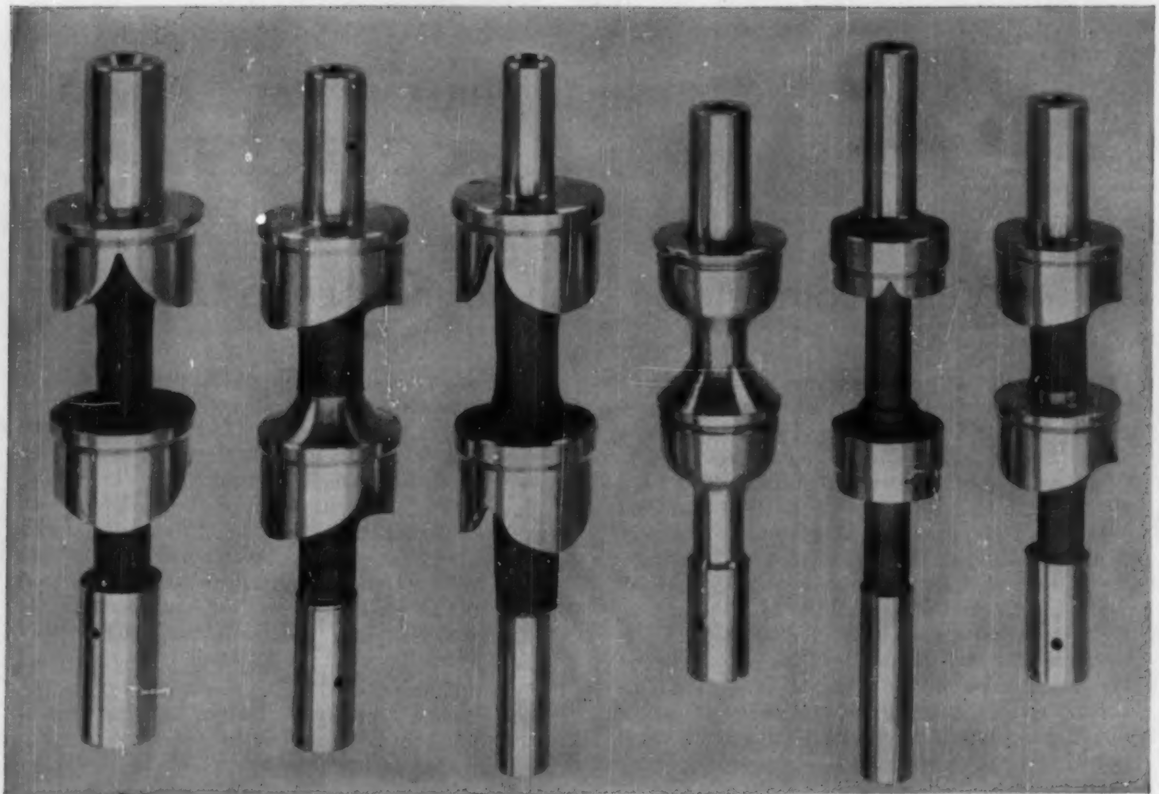
Symptomatic, also, is the current flurry of American chemical activity in Europe, and the rash of joint ventures being set up by American and European chemical companies.

Informed opinion tends to believe that the integration of the chemical industry of the U. S. Western Europe, Japan, Australia, and certain other advanced countries—a block of some 500 million population—can be carried out over a decade or two in an orderly fashion, with only minor inequalities and dislocations along the road.

The small non-economy size

What, on the other hand, is the threat posed by development of the chemical industry in that vast area of the Free World, for the most part neutralist or uncommitted politically, where wage rates are almost ridiculously low compared to American or European standards?

Not serious say American chemical analysts Reason—for the time being at least, in contrast to the centripetal tendencies at work in Europe and between Europe and the U. S., we are witnessing in the rest of the Free World a sort of splintering movement rather than an integration of economic development. Along with political independence, each small nation, including many of the newly-formed states in Africa, seems to want its own private little chemical industry, even if this means erection of plants which in the U. S. would be so small as to make economic operation impossible. This sort of production, while it may satisfy the national pride (and in some cases the strategic aims) of the smaller nations, stands no chance whatsoever of being able to compete successfully in the world market, much less invade the American domestic market.



opinion and comment

Future is up to you

Guest editorial by Jerry McAfee, A.I.Ch.E. President.

OURS IS A GREAT AND NOBLE profession. It is vital, dynamic, creative, aggressive, constructive. Its past is bright with accomplishment; its future is equally bright with promise. We must keep it that way.

It is altogether fitting and proper that we should band together—as some 20,000 or so of us have done in the A.I.Ch.E.—to do certain things which can be done better together rather than separately. Through the Institute we provide opportunities for chemical engineers to meet together, we disseminate and record technical information, we sponsor appropriate technical projects, and we strive to maintain and even raise the high professional standards which have characterized chemical engineering from its beginning.

It is specially appropriate that as a group we should, from time to time, critically and objectively examine our profession—as the Dynamic Objectives Committee has done this year—to determine where we are, where we should be going, and how best to get there.

There is probably nothing more important than continued emphasis on maintaining the high standards of chemical engineering education. We must see to it that the changing needs of our world for the skills which chemical engineers can and should supply are properly provided for by adequate training. We must make sure that our profession takes full advantage of the explosive new developments in scientific knowledge which are available today on an ever-increasing scale.

These and many other things we can do best as a professional group. There is no better mechanism now available than the A.I.Ch.E. for doing those things which need to be done for the profession in this way.

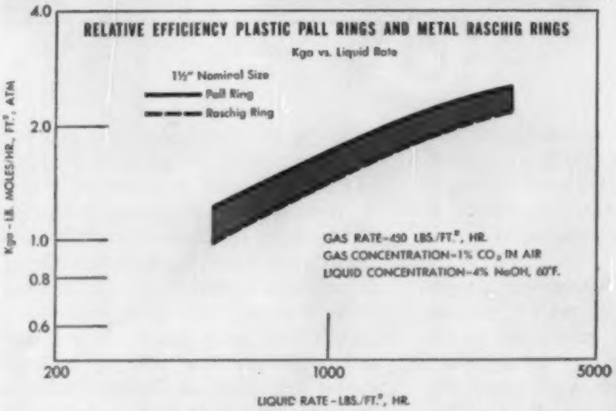
But in the final analysis it is what we are and what we do as *individuals* that really counts. It is the sum total of our *individual* accomplishments which make up the accomplishments of our profession. Even in this day of tremendous research and engineering establishments, and great inter-disciplinary task force teams of scientists and engineers, it is still to the *individual* mind that the Lord in His wisdow reveals a new truth here, a new insight there. Each of us has to make his own contribution if our way of life is to continue to progress and survive. True, these individual efforts must be harmonized with those of others, since our complex society requires the co-ordinated application of the efforts of many people, but we cannot escape our personal responsibility for adding our small bit to the world's progress —or to its decline if we fail to do our part.

And when it comes to professional status and recognition and standing —about which we hear so much these days—it is just as surely what we are and do as individual chemical engineers that is really important. The world will not accord us the professional status we seek unless we really deserve it. Whether we receive recognition as a true profession depends on whether or not we are indeed professionals—and this is a highly personal matter depending entirely on you and me.

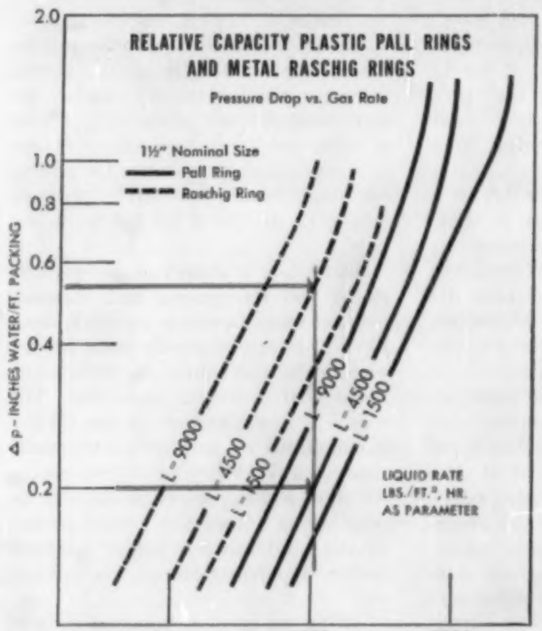
While we owe an immense debt to the chemical engineers who have preceded us, and while there is much we can and should and will do *together*—through the Institute and otherwise—to advance our profession, finally and basically the future of our profession is really up to you and me as *individual* chemical engineers. We can make a great profession even greater—and I believe we will!

J. MCAFEE

HIGH CAPACITY HIGH EFFICIENCY PALL RINGS in PLASTIC



Kga data, obtained in one of our 30" experimental towers, reflects the much greater efficiency of plastic Pall Rings.



Pressure drop data likewise reflects the high capacity of plastic Pall Rings. For example, pressure drop through metal Raschig Rings at a gas rate of 1000 lbs./ft.², hr., and a liquid rate of 4500 lbs./ft.², hr., is almost three times greater than through plastic Pall Rings.

The remarkably efficient Pall Ring, first introduced on the American market in 1957, in metal, is now available in polypropylene and high density polyethylene;* in four sizes: ⅝", 1", 1½" and 2".

Pall Rings in plastic offer the same striking advantages of low pressure drop and high capacity at less than one-fourth the weight. (For example, 1½" Pall Rings in carbon steel weigh approximately 23½ lbs. per cu. ft. In plastic, only 4¼ lbs.)

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CEP feature

JOEL H. HIRSCH AND EDWIN M. GLAZIER
Gulf Research & Development Co.

Estimating plant investment costs

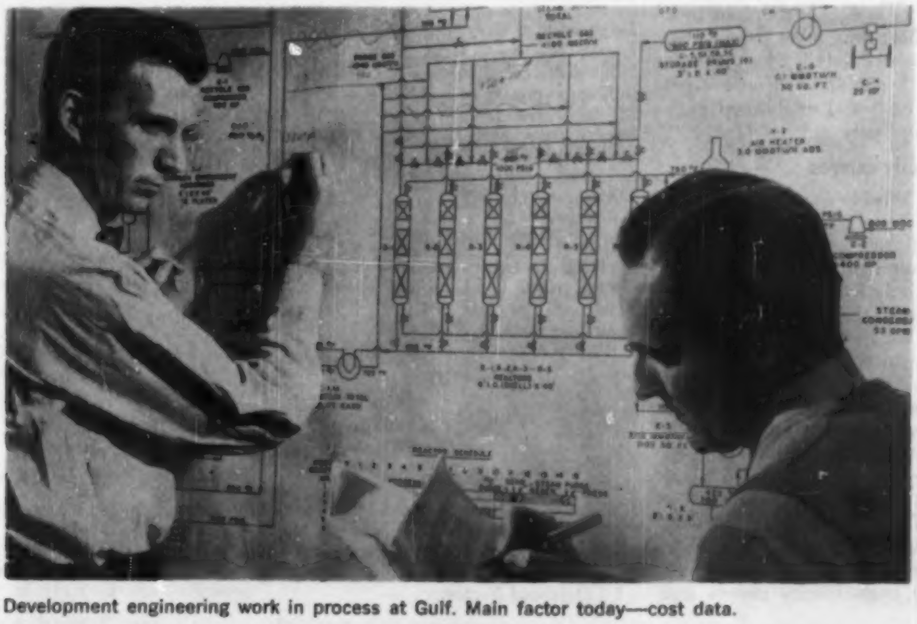
Compute your total plant investment by this improved method using size and cost of basic equipment in the process design.

NO FEATURE DISTINGUISHES the chemical engineer of today from his counterpart of a generation ago more than the extent to which economics enters into his every activity. Cost estimating and economic evaluation are interwoven into every part of the fabric of modern process research, development, and design.

This is especially true in the development of new processes. Time was when the research scientist, process design engineer, and investment cost estimator worked in more or less isolated compartments with relatively little contact. The process designer—usually a chemical engineer—was often handed a frozen process concept after research had been virtually completed and when there was little chance for him to influence the work through engineering calculations that might have resulted in a more nearly optimum balance of the process variables. He then made a process design that was subsequently submitted to an estimating department—composed largely of civil and mechanical engineers—for structural design, plant layout, and cost estimating. That this compartmentalized, sequential procedure achieved, on the whole, fairly satisfactory results is a tribute to the patience and experience of all concerned. General estimating departments perform an indispensable function in preparing detailed authorization estimates for those projects that finally come to fruition, but their type of operation and estimating is not suited to guidance of either research or design work in progress.

The cost data book

If the process engineer achieves anything approaching an optimum design under the sequential procedure, it is only because he has seen



Development engineering work in process at Gulf. Main factor today—cost data.

so many designs pass through the laborious research - design - estimating sequence that he has developed an intuitive feel for what constitutes economical design. Nevertheless, this procedure is as unsound in principle as having one engineer make the material balance for a new process and another make a heat balance. Material, heat, and economic balances are intimately interlinked, and it is only by treating them as such at each stage of progress, from research to commercialization, that optimum results can be obtained. Under this concept, the cost data book should occupy a place beside the technical data book on the process designer's desk, both at the development engineering and final engineering stages. These books provide codified procedures and reasonable consistency in the results, even when several engineers participate in the work. This consistency is indispensable to day-to-day direction of research, development, and design, to appraisal of the final results, and to management decisions in the choice among competing projects.

In the cost data book, no section is more important than that dealing with the estimating of plant investment costs for new processes. It is to this phase of the work that this article is devoted—particularly to the handling of processes at the development - engineering stage, when research is still in progress and where considerable technical and economic guidance is required with all possible dispatch.

For this type of work, the ability to perform economic evaluations in a relatively short time takes precedence over precision of detail. This requires the ready availability of correlated equipment costs and established evaluation procedures.

Cost capacity curves

Prior to World War II, there was practically no published information on process equipment costs or on plant investment costs. (Weaver *(1-6)* lists only five references before 1941.) During the latter part of this period we began to develop a systematic procedure for estimating plant investment. Our early work centered around the development of cost-capacity curves for process equipment and an installation factor to proceed from basic equipment costs to plant investment costs. Starting with a few contractors' proposals for refinery units, we found it possible to correlate isolated pieces of data and to develop satisfactory cost-capacity curves and installation factors. Then, with a good preliminary process design, we were able to use the cost-capacity curves to calculate basic equipment costs and the installation factor to obtain the battery-limits investment, using a relationship such as:

$$I = E\ (FA_T + B) \tag{1}$$

In 1946, *Chemical Engineering* started publishing a series of articles (7) on "Data and Methods for Cost Estimation." It was gratifying to find that our cost-capacity curves for process equipment were not too different from those published *(8-10)*. It was particularly useful to have cost curves available for the many additional items published during 1948 and 1949 *(11)*.

In 1947-1948, the *Chemical Engineering* series contained several articles *(15-17)*, one of which presented an installation factor of 3.63 to be used in estimating plant investment costs from basic equipment costs. The figure we were using at the time was 3.7. Later, we were able to derive a factor of 3.6 from Nelson's data *(12)* when used on a comparable basis.

About this time, we were concerned with the accuracy of our method. We had found that we could predict investment costs for the plants used in developing our correlations with a deviation of about ±15%. However, this was for a relatively small sample over a narrow range of plant types. We were not sure how this compared with others or how well we could predict a dissimilar plant. From some of Nelson's articles *(12, 13)* we were able to obtain a breakdown of the items which needed to be accounted for by the installation factor, as well as the range over which these items varied. By statistical procedures, it was possible to calculate a variation of only ± 13.9% for the over-all installation factor, despite variations several times as great in individual items making up this factor. These calculations, shown in Table 1, explained why a single installation factor could produce such surprisingly close checks with detailed estimates and indicated a suitable reliability of prediction on future problems. A 1950 article *(18)* discussed four estimates made at different stages in the development of a process. An acceptable accuracy for these estimates was stated to range from ± 75%, at a preliminary stage in the development, to ± 10% when the process reached the semiworks stage. On this basis, our results seemed to

Table 1. Accuracy of installation factor.

	Average[1] percent of direct plant cost	Fraction of basic equipment cost	Range[2] of value, %	Range of fraction	Range squared
Basic equipment	23.6	1.000	± 20	± 0.054	0.002916
Installation	6.4	0.271	± 35	± 0.423	0.178929
Piping	28.5	1.208	± 63	± 0.059	0.003481
Insulation	2.2	0.093	± 50	± 0.170	0.028900
Instruments	8.0	0.339	± 33	± 0.021	0.000441
Foundations	1.5	0.064	± 71	± 0.051	0.002601
Structural steel	1.7	0.072	± 50	± 0.170	0.028900
Buildings (process)	8.0	0.339	± 60	± 0.051	0.002601
Electrical wiring	2.0	0.085	± 50	± 0.023	0.000529
Sewers, tools, etc.	1.1	0.047	± 60	± 0.051	0.002601
Field Supervision	2.0	0.085			
Acceptance tests	4.0				
Engineering and designs	7.0				
Home office expense	4.0				
Direct plant cost	100.0	3.603[3]			0.251899
Contingencies	10.0				
Profit	10.0				
Insurance, taxes liabilities	4.5				
Total plant cost	124.5				

$$\pm\sqrt{0.251899} = \pm 0.5019$$

$$\text{Range of installation factor} = \frac{\pm 0.5019}{3.603} = \pm 13.9\%$$

[1] "Costimating" No. 14, W. L. Nelson, *Oil & Gas J.*, 1-20-49, representing Nelson's Average of Values in "Costimating" No. 8, *Oil & Gas J.*, 12-9-48.
[2] Range of Variation of Items in Nelson's "Costimating" No. 8.
[3] Items which we included in our 3.7 Installation Factor. Other items included in our 1.4 Overhead Factor.

be satisfactory. More recently, Hackney (*19, 20*) has given the following figures on the probable accuracy attainable in various stages of estimating:

Equipment ratio method	± 25%
Layout method	± 12%
Preliminary bill method	± 6%
Detailed unit cost method	± 3%

We believe these figures are reasonably representative of current practice—and the accuracy of our method still seems to be satisfactory.

Plant size an important factor

In our early work, it seemed that the installation factor varied with time to a greater extent than could be accounted for by the *ENR Index. There appeared to be a leveling off after 1946 at the previously mentioned figure of 3.7. Continued development, and further investigation, showed this to be a misconception. An effect of plant size was indicated. Instead of remaining constant at 3.7, the installation factor was found to decrease with an increase in the cost of basic equipment, as shown by the following equation:

$$F = 5.756\ (A_T)^{-0.0348} \qquad (2)$$

Further development has modified this equation to include the effects of other factors such as field labor, piping material, and alloy equipment. At one stage we derived separate installation factors for different categories of equipment, such as published by Nelson (*14*). Skipping over several intermediate equations developed through the years, we arrived at the one in current use. Total battery-limits investment is now calculated using the following equation:

$$I = E\ [A\ (1 + F_L + F_P + F_M)\ + B + C] \qquad (3)$$

The three installation cost factors, F_L, F_M, and F_P, are defined by:

$$\log F_L = 0.635 - 0.154 \log A_o - 0.992\left(\frac{e}{A}\right) + 0.506\left(\frac{f}{A}\right) \qquad (4)$$

$$\log F_P = -0.266 - 0.014 \log A_o - 0.156\left(\frac{e}{A}\right) + 0.556\left(\frac{p}{A}\right) \qquad (5)$$

$$F_M = 0.344 + 0.033 \log A_o + 1.194\left(\frac{t}{A}\right) \qquad (6)$$

The cost relative to total basic equipment of each of the following

*Engineering News Record

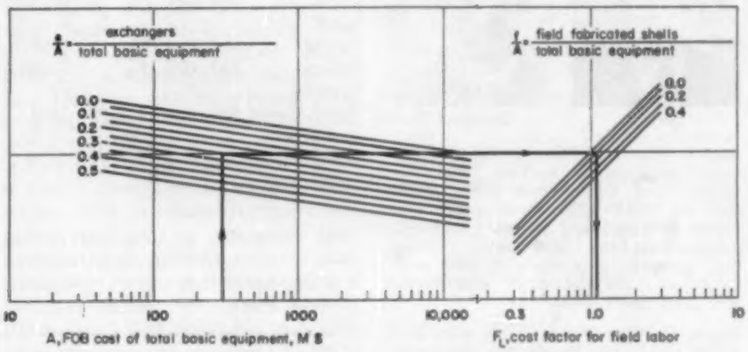


Figure 1. Cost factor for field labor. ENR Index=700.

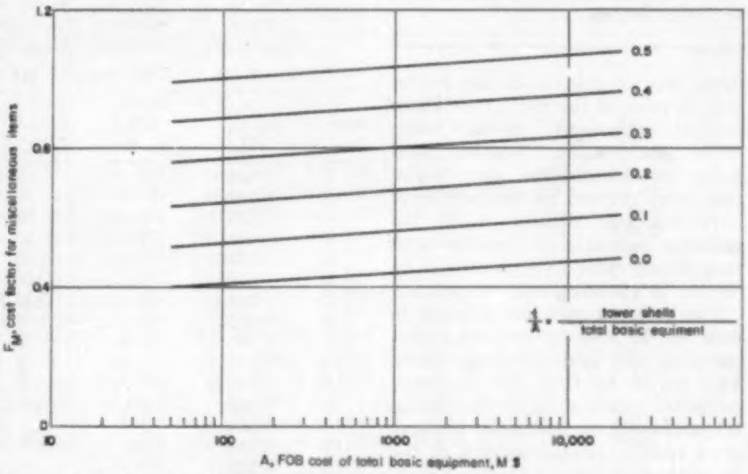


Figure 2. Cost factor for piping. ENR Index=700.

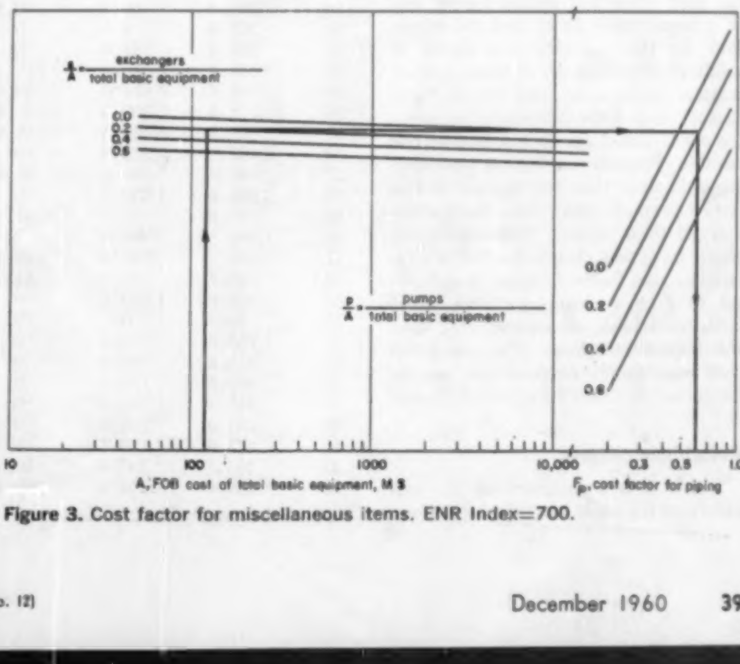


Figure 3. Cost factor for miscellaneous items. ENR Index=700.

Hirsch

Glazier

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items was considered in the derivation of each of the three installation factors: exchangers, pumps, tower shells, compressors, field-fabricated shells, and incremental alloy. Equations were derived by the method of sequential least squares, testing the variables successively. Variables with insignificant effect were eliminated by the use of statistical tests of variance.

The present correlation is based on data for 42 separate refining, petrochemical, and synthetic fuels plants. The use of an IBM 704 electronic computer greatly reduced the manual calculations, and the computer program enables prompt revision of the correlations as new data become available.

It will be noted that the equations for field labor and piping factors are of a logarithmic form, and the equation for the miscellaneous factor is semilogarithmic. Both of these mathematical forms were tried for all three factors and little difference in accuracy was noted on comparison of the resulting equations. This is probably an indication that the spread of the data has more effect than the mathematical form chosen. The semilogarithmic form was chosen for the miscellaneous cost factor because it appeared to give a more consistent trend with total basic equipment cost than the logarithmic form. The equations that were finally adopted can readily be solved by use of Figures 1, 2, and 3.

Reliability criteria

Table 2 is a summary of the calculations for each individual estimate. The following is a tabulation of the statistical results:

Field labor	Std. dev. F_L	0.3307
Piping	Std. dev. F_P	0.1878
Miscellaneous	Std. dev. F_M	0.3067
Total direct investment	Std. dev. I/E(%)	16.4
Total direct investment	Avg. dev. I/E(%)	12.4

In comparing a calculated investment with one from an outside source, it is important that the two estimates include comparable direct and indirect costs as well as the same items of equipment. Normally, the factor E, representing indirect costs, is given a value of 1.4 which is broken down as follows:

Engineering and supervision	15%
Overhead and profit	15%
Contingencies	10%
	40% of direct costs

For processes under development, this factor can be expected to be different from that for well-established processes. Since evaluation of this

Table 2. Summarized data for plant investment estimates.

(All Data at ENR Index = 700)

Est. No.	Total Basic Equipment Cost, M$ A_o	Total Erected Equipment Cost, M$ B	Total Incremental Alloy Cost M$ C	Total Direct Investment, Calculated M$ I/E	Total Direct Investment, Observed M$ I/E	% Deviation $100\frac{\text{obs.-calc.}}{\text{calc.}}$
1	119.0	0	9.6	347.6	291.0	−16.3
2	102.0	0	6.2	284.0	220.1	−22.5
3	425.7	286.0	54.8	1,494.0	1,441.0	−3.5
4	662.9	383.2	82.4	2,271.3	2,152.6	−5.2
5	174.5	6.5	5.3	504.1	512.7	1.7
6	178.2	112.0	106.1	798.5	833.0	4.3
7	984.0	641.2	245.6	3,485.5	4,569.0	31.1
8	373.7	227.0	6.8	1,424.4	1,389.7	−2.4
9	1,090.9	648.6	72.2	3,763.3	5,141.2	36.6
10	55.7	2.7	1.2	219.4	186.3	−15.1
11	65.2	2.7	1.2	230.2	211.2	−8.3
12	3,462.3	1,168.6	1,454.4	—	7,853.6	—
13	319.7	206.4	120.3	1,668.8	1,677.6	0.5
14	3,152.7	366.3	278.7	10,081.0	11,502.1	14.1
15	128.7	0	0	409.8	396.8	−3.2
16	87.6	0	0	289.5	297.5	2.8
17	711.8	523.3	0	2,892.2	3,230.1	11.7
18	252.9	0	28.4	966.7	1,005.6	4.0
19	1,384.8	60.4	190.3	4,772.1	6,445.7	35.1
20	358.6	0	0	1,255.5	1,272.1	1.3
21	824.4	82.5	0	2,697.5	3,314.4	22.9
22	3,214.4	1,586.0	216.1	10,715.6	11,305.3	5.5
23	21,604.4	5,613.0	3,726.3	65,770.0	62,089.3	−5.6
24	11,712.4	2,900.8	3,017.3	35,386.5	31,440.4	−11.1
25	18,611.3	6,103.8	1,156.5	62,908.1	54,824.0	−12.9
26	2,494.0	7,235.9	0	—	12,483.3	—
27	646.6	383.2	66.9	2,680.2	2,337.8	−12.8
28	3,963.6	1,650.9	0	12,760.9	13,805.5	8.2
29	110.8	73.7	181.4	572.9	605.5	5.7
30	1,382.5	961.8	0	4,716.7	5,541.7	17.5
31	4,684.2	741.4	942.3	14,181.1	12,298.3	−13.3
32	1,743.7	657.1	61.9	7,085.3	6,161.3	−13.0
33	2,424.0	1,973.8	0	8,967.0	8,482.7	−5.4
34	20.3	0	0	74.6	87.3	17.0
35	1,786.8	214.5	0	6,664.9	6,138.4	−7.9
36	813.8	186.9	0	3,085.7	3,574.2	15.8
37	480.5	178.8	0	1,811.5	2,450.2	35.3
38	1,945.8	242.0	0	7,182.7	6,620.3	−7.8
39	1,063.3	181.2	0	3,949.5	4,168.8	5.6
40	455.6	139.7	0	1,666.4	2,297.9	37.9
41	591.7	145.2	38.3	1,876.4	1,636.3	−12.8
42	1,296.4	133.2	260.0	4,531.3	4,320.9	−4.6

[1] Estimated as negligible. [2] Unknown.

factor is less accurate than our correlations for direct plant investment, estimates should normally be compared on the direct-cost basis: $I/E = A(1+F_L+F_P+F_M) + B + C$. Care should be taken to determine what direct costs are included in the quoted estimate, and what, if any, indirect costs are included. If a packaged auxiliary unit such as a gas purification unit or oxygen generator is included in the plant specifications, it is preferable to back out the cost of this unit from the estimate before comparison.

A summary breakdown of observed investment costs is given in Table 3 and a sample calculation is included as Table 4.

In estimating investments for several chemical plants containing a high proportion of alloy equipment, it was found that inclusion of the incremental alloy cost in the basic equipment cost A resulted in excessive installation charges. This is due to the fact that use of alloy materials greatly increases the FOB cost of equipment, but has little effect on that portion of the installation costs accounted for by erection labor, foundations, instruments, insulation, etc. Therefore, the incremental alloy cost has been eliminated from the installation factor expression, $A(F_L+F_P+F_M)$, by appropriate definition of the A term. For high-temperature service, alloy materials are often used, either because they are more economical than carbon steel at the given conditions, or because carbon steel is physically inadequate. In such cases, the cost of these alloys should be considered as a basic equipment cost rather than an incremental alloy cost. For example, the cost of a reactor shell designed for 950° F service and fabricated of Grade A-301-B low-alloy steel should be included in the basic equipment cost term A, but the cost of an alloy liner or alloy cladding for this shell should be included in the incremental alloy cost C. In addition, for the sake of convenience, Admiralty heat exchanger tubes and Naval Brass tube sheets should be included in basic equipment costs.

When calculating FOB costs for a plant, the carbon steel and incremental alloy costs should be listed separately, as shown in the sample calculation, Table 4. This will facilitate calculation of the total basic equipment and incremental alloy cost terms, and the calculation of the cost factor parameters.

For estimating the cost of fluid-solids plants or all-solids plants, the following equation is recommended:

$$I = E\,[A(1+F_M) + A_f(F_L+F_P)_f + A_s\,(0.65F_L)_s + C + B] \quad (7)$$

Relative Cost Parameters					Cost Factors, Obs.			Cost Factors, Calc.			
Exchangers e/A	Pumps + Drivers p/A	Tower Shells t/A	Field Fabr. Shells f/A	Incr. Alloy c/A	Field Labor F_L	Piping F_P	Misc. F_M	Field Labor F_L	Piping F_P	Misc. F_M	Est. No.
0.471	0.103	0.195	0	0.081	0.543	0.400	0.423	0.705	0.489	0.646	1
0.517	0.081	0.163	0	0.061	0.395	0.390	0.312	0.650	0.468	0.605	2
0.463	0.069	0.191	0	0.129	0.733	0.492	0.359	0.590	0.460	0.659	3
0.409	0.120	0.137	0	0.124	0.327	0.444	0.774	0.624	0.499	0.601	4
0.407	0.109	0.111	0	0.030	0.558	0.608	0.704	0.769	0.501	0.551	5
0.323	0.262	0.236	0	0.596	1.000	0.810	0.639	0.929	0.628	0.700	6
0.520	0.170	0.196	0	0.250	0.899	0.659	1.184	0.456	0.508	0.677	7
0.326	0.234	0.280	0	0.018	0.986	0.430	0.677	0.824	0.599	0.763	8
0.450	0.195	0.235	0	0.066	1.008	0.836	1.208	0.527	0.537	0.725	9
0.198	0.368	0.185	0	0.021	1.402	0.759	0.114	1.480	0.766	0.623	10
0.276	0.285	0.158	0	0.002	1.360	0.753	0.070	1.211	0.667	0.593	11
0.310	0.038	0.044	0	0.420	0.554	0.173	[2]	0.607	0.454	—	12
0.238	0.096	0.441	0.441	0.376	1.526	0.587	1.112	1.726	0.519	0.953	13
0.177	0.064	0.076	0.108	0.088	1.113	0.602	0.729	0.949	0.493	0.551	14
0.341	0.112	0.263	0	0	0.840	0.456	0.788	0.938	0.518	0.728	15
0.348	0.126	0.325	0	0	0.912	0.429	1.056	0.980	0.529	0.796	16
0.283	0.170	0.293	0.154	0	1.791	0.458	0.554	0.984	0.556	0.788	17
0.137	0.068	0.351	0	0.112	1.340	0.517	1.006	1.346	0.521	0.843	18
0.151	0.091	0.088	0.146	0.137	1.383	0.905	1.184	1.191	0.521	0.553	19
0.175	0.150	0.279	0	0	1.028	0.617	0.903	1.170	0.569	0.762	20
0.193	0.109	0.178	0	0	1.491	0.819	0.610	0.989	0.530	0.653	21
0.239	0.084	0.082	0	0.067	0.911	0.486	0.559	0.721	0.494	0.558	22
0.176	0.095	0.000	0.004	0.172	0.471	0.373	0.598	0.625	0.500	0.487	23
0.250	0.044	0.000	0	0.258	0.440	0.474	0.265	0.577	0.460	0.479	24
0.028	0.052	0.094	0	0.062	0.539	0.428	0.588	0.893	0.500	0.597	25
0.290	0.002	0.025	0.036	0	1.350	0.572	[2]	0.697	0.439	—	26
0.171	0.093	0.342	0	0.103	1.119	0.675	0.125	1.079	0.525	0.845	27
0.302	0.129	0.151	0.060	0	0.943	0.620	0.504	0.649	0.511	0.643	28
0.430	0.152	0.120	0	1.636	0.733	0.951	0.477	0.784	0.529	0.555	29
0.266	0.072	0.005	0	0	0.976	0.903	0.434	0.773	0.489	0.454	30
0.296	0.042	0.101	0.037	0.201	0.393	0.386	0.487	0.625	0.457	0.586	31
0.066	0.124	0.027	0.266	0.036	1.082	0.530	0.509	1.607	0.560	0.484	32
0.296	0.097	0.229	0	0	0.524	0.445	0.715	0.662	0.494	0.729	33
0.355	0.159	0.435	0	0[1]	1.667	0.326	1.297	1.205	0.561	0.907	34
0.068	0.559	0.011	0	0[1]	1.163	0.745	0.407	1.170	0.975	0.465	35
0.114	0.520	0.008	0	0[1]	1.488	0.952	0.721	1.189	0.923	0.450	36
0.176	0.460	0.006	0	0[1]	1.730	1.106	0.890	1.117	0.841	0.440	37
0.072	0.551	0.008	0	0[1]	1.151	0.737	0.390	1.143	0.962	0.462	38
0.106	0.526	0.010	0	0[1]	1.328	0.849	0.573	1.159	0.929	0.456	39
0.194	0.453	0.006	0	0[1]	1.714	1.094	0.929	1.082	0.830	0.439	40
0.251	0.097	0.000	0	0.065	0.512	0.453	0.491	0.912	0.513	0.436	41
0.157	0.086	0.188	0	0.201	0.906	0.461	0.662	1.003	0.518	0.671	42

Table 3. Breakdown of plant investment costs.

Cost item	Representative term for erected investment equation	Observed values for correlated estimates: Percent of basic equipment cost, A — Min.	Avg.	Max.	Percent of total miscellaneous cost — Min.	Avg.	Max.	Percent of total direct cost — Min.	Avg.	Max.
DIRECT COSTS	$A(1+F_L+F_P+F_M)+B+C$									
Basic equipment, FOB basis	A									
Erected equipment	B									
Incremental alloy	C									
Field labor for FOB, piping and misc. items	F_L	33.0	100.0	180.0						
Piping materials	F_P	17.0	61.0	111.0						
Miscellaneous items	F_M	11.0	65.0	130.0						
Insulation					2.9	7.5[1]	13.4			
Instruments					6.9	14.5[2]	25.3			
Foundations					5.4	12.7[1]	34.2			
Structural steel					5.4	14.5[1]	27.3			
Buildings (process)					1.8	8.2[3]	32.4			
Electrical wiring, switch gear, etc.					2.9	8.8[1]	21.6			
Fireproofing and control					0.7	1.8[4]	3.5			
Painting					0.6	1.1[5]	2.0			
Site preparation and sewers					1.2	4.7[3]	13.9			
Field supervision					5.2	9.4[6]	22.5			
Freight					4.4	7.6[6]	23.1			
Temporary structures and miscellaneous					2.9	7.8[6]	19.3			
INDIRECT COSTS										
Engineering and supervision (15% of direct costs)								9.6	14.0	17.4
Engineering								6.5	9.1[7]	13.8
Construction tools and freight on tools								2.2	3.8[6]	5.1
Inspection and expediting								0.9	1.1[7]	2.3
Acceptance tests									–[8]	
Contractors overhead and profit (15% of direct costs)										
Home office expense								0.7	0.8[7]	1.0
All insurance and taxes								1.9	2.5[4]	3.2
Purchasing									–[8]	
Traveling expense									–[8]	
Profit									–[8]	
Contingencies (10% of direct costs)										

[1] Costs listed specifically in 32 of 42 correlated estimates.
[2] Costs listed specifically in 23 of 42 correlated estimates.
[3] Costs listed specifically in 31 of 42 correlated estimates.
[4] Costs listed specifically in 13 of 42 correlated estimates.
[5] Costs listed specifically in 14 of 42 correlated estimates.
[6] Costs listed specifically in 22 of 42 correlated estimates.
[7] Costs listed specifically in 9 of 42 correlated estimates.
[8] Costs not reported.

As indicated in Table 2, data for complete units were used in developing the correlations presented. The procedure is not recommended for estimating the cost of revisions to existing plants.

Economic evaluation has come a long way in the past fifteen years with something like 2000 references listed in one bibliography series alone (*1-6*). The use of electronic computers in design, optimization, and evaluation is being actively investigated and will permit evaluation of as many variations as the engineer wishes to investigate. This will permit a greater degree of optimization and investigation of variables than has ever been possible before.

It seems fitting to end on a note of caution. The introduction of this article stressed the handicaps of a process engineer lacking economic background—background which procedures of the present type are intended to supply. It is also necessary to stress the harm that may result from economic procedures such as this in inexperienced hands. Just as a technical data book is no substitute for chemical engineering experience, a good cost data book is an adjunct to, not a substitute for, an experienced designer. No economic evaluation is better than the process design on which it is based.

Notation

A = total cost of all battery-limits equipment estimated on an FOB basis. This cost is exclusive of any incremental cost for alloy materials when such materials are used only because of their corrosion-resisting properties.

A_o = A, expressed in *M$*.

A_T = total cost of *all* basic equipment estimated on an FOB basis $= A + C$

B = cost of all equipment estimated on an erected basis, such as furnaces, tanks, cooling towers, etc.

C = incremental cost of alloy materials provided these materials are used only for their corrosion-resisting properties. Thus for an alloy pump used for corrosive service, the cost of a carbon steel pump of identical design would be included in the total basic equipment cost, A, and the *incremental alloy cost* (i.e., cost of the alloy pump minus cost of the carbon steel pump) would be included in C.

E = indirect cost factor representing contractors' overhead and profit, engineering, supervision, and contingencies. E is normally given a value of 1.4.

F = installation factor.

F_L = cost factor for field labor, Figure 1; thus, $F_L \times A$ is the total cost for field labor, less supervision, and excluding the labor

Table 4. Sample calculation.

1. Summary of FOB Costs	Cost Calculated on Carbon Steel Basis (1)	Total Calculated Cost (Including Incremental Alloy) (2)	Incremental Cost of Alloy (2) - (1)
Towers			
Shells, diam. ≦ 12 ft.	$ 105,100		
Shells, diam. > 12 ft.	31,500	$173,800[1]	$142,300
Total trays and internals	203,000	249,000[1]	46,000
Drums			
Diam. ≦ 12 ft.	41,300		
Diam. > 12 ft.	51,000		
Miscellaneous vessels			
Shells, diam. ≦ 12 ft.	—		
Shells, diam. > 12 ft.	161,000		
Total internals	22,500		
Heat exchangers	564,900		
Pumps	74,000		
Pump drives	58,400		
Compressors	760,000		
Miscellaneous FOB equipment	29,100		
Total of FOB costs	$2,101,800		$188,300
2. Summary of Erected Equipment Costs			
Fired heaters		182,000	
Tankage		5,300	
Total of erected equipment costs		$187,300	

3. Calculation of Direct Investment, I/E

$A = \$2{,}101{,}800$
$B = 187{,}300$
$C = 188{,}300$
$p/A = (74{,}000 + 58{,}400)/2{,}101{,}800 = 0.063$
$e/A = 564{,}900/2{,}101{,}800 = 0.269$
$t/A = (105{,}100 + 31{,}500)/2{,}101{,}800 = 0.065$
$f/A = (31{,}500 + 51{,}000 + 161{,}000)/2{,}101{,}800 = 0.116$

$F_L = 0.822$ (Figure 1)
$F_P = 0.479$ (Figure 2)
$F_M = 0.532$ (Figure 3)
$I/E = A(1+F_L+F_P+F_M) + B + C$
$I/E = 2{,}101{,}800\,(1 + 0.822 + 0.479 + 0.532) + 187{,}300 + 188{,}300$
$I/E = \$6{,}330{,}000$

[1] For FOB equipment, only those items which contain incremental alloy, as defined in the text, need be listed in this column.

charges included in the B term.

F_M = cost factor for miscellaneous items, Figures 3; $F_M \times A$ includes the materials cost for insulation, instruments, foundations, structural steel, buildings, wiring, painting, and the cost of freight and field supervision.

F_P = cost factor for piping materials, Fgure 2; $F_P \times A$ is the total cost of piping materials including pipe, fittings, valves, hangers and supports, but excluding insulation and installation labor charges; this labor cost is included in F_L.

I = total battery-limits investment, dollars.

e = total heat exchanger cost (less incremental cost of alloy).

f = total cost of field-fabricated vessels (less incremental cost of alloy). Any vessel with an inside diameter larger than 12 ft. should be considered as field-fabricated unless specifically designated as shop-fabricated.

p = total pump plus driver cost (less incremental cost of alloy).

t = total cost of tower shells (less incremental cost of alloy).

Subscripts

$_f$ pertains to fluids-processing equipment.

$_s$ pertains to solids-handling equipment.

ACKNOWLEDGMENT

Development of this procedure, extending over about fifteen years, has involved contributions from a number of persons, including most of the authors' associates during that period. The number being so large, it seems best to make collective acknowledgment, with special mention of W. C. King for outstanding work in developing the cost factor relationships, and L. W. Patterson, Jr. for preparing the current revision of the procedure. Finally, sincere appreciation is expressed to Gulf R&D Co. for permission to present this paper.

LITERATURE CITED

1. Weaver, J. B., *Chem. Eng.*, *61*, No. 10, 185 (1954).
2. *ibid*, *62*, No. 6, 247 (1955).
3. Weaver, J. B., *Ind. Eng. Chem.*, *48*, No. 5, 934 (1956).
4. *ibid*, *49*, No. 6, 986 (1957).
5. *ibid*, *50*, No. 5, 753 (1958).
6. *ibid*, *51*, No. 5, 639 (1959).
7. Happel, J., R. S. Aries, and W. J. Borns, *Chem. Eng.*, *53*, No. 10, 99 (1946).
8. Bliss, H., *Chem. Eng.*, *54*, No. 5, 126 (1947).
9. *ibid*, *54*, No. 6, 100 (1947).
10. Chilton, C., *Chem. Eng.*, *56*, No. 6, 97 (1949).
11. Nelson, W. L., *Oil & Gas J.*, *47*, 141 (10-21-48).
12. *ibid*, *47*, 117 (12-9-48).
13. *ibid*, *47*, 97 (1-20-49).
14. *ibid*, *49*, 263 (10-5-50).
15. Lang, H., *Chem. Eng.*, *54*, No. 9, 130 (1947).
16. *ibid*, *54*, No. 10, 117 (1947).
17. *ibid*, *55*, No. 6, 112 (1948).
18. Howey, C. R., *Chem. Ind.*, *67*, No. 5, 724 (1950).
19. Hackney, J. W., *Chem. Eng.*, *67*, No. 5, 113 (1960).
20. *ibid*, *67*, No. 7, 119 (1960).

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Off-site investment and working capital

Process profitability picture is dependent upon off-site costs, working capital, as well as battery limits investment.

Estimation of off-site investment for proposed projects is a vital element of any cost analysis. However, since these are not a part of the "heart" or "battery limits" of the process, they are sometimes either overlooked or omitted on the assumption that they amount to very little and will have no significant bearing on the profitability picture of the proposal. Also, the inclusion of working capital requirements is often felt unnecessary.

Off-site costs can be quite large in proportion to battery limits costs, exceeding 100% of these costs in some cases. In addition, providing for working capital is necessary to assure start-up and continued operation of a given process. These two items must be considered along with the battery limits investment in any adequate and completely descriptive profitability analysis.

Off-site data are presented here primarily in the form of cost vs. capacity curves and the reliability is probably no better than ± 25%. Published data are used as a basis for the correlations and explanations are offered in a few instances where actual experience differs with published costs. Articles on estimation of process plant auxiliary costs (*1*) and estimation of off-site facilities (*2, 3*) have been published.

Off-site investment costs

Off-site facilities are considered to be all equipment, lines, utilities, etc., located outside the area occupied by the process unit itself. Off-site costs are presented on two bases. First, the total off-site investment requirements are presented in the form of percentage factors based on battery limits investment. Second, more specific cost information on individual off-site facilities are presented.

Off-site costs in proportion to the battery limits investment depends primarily upon whether the plant or unit being considered is brand new or whether it is a moderate or a major addition to an existing plant.

A summary of off-site costs is presented in Figure 1. If the unit to be added requires a minimum of off-site facilities, the cost would be in the vicinity of 15% of the battery limits investment. More often the cost will approach 30% since there are often a number of fairly sizeable costs which are rarely avoidable, such as steam and/or power additions, storage tanks and lines, and cooling towers.

If the plant under consideration is brand new (grass-roots), then off-site costs may be in the range of 120% of the total battery limits investment.

The accuracy of the data in Figure 1 is fairly low because large variations in circumstances surround each plant consideration. Some factors influencing this situation are: manufacturing vs. purchasing utilities, magnitude of the battery limits investment, inventory and storage policies, and general economic conditions prevailing at the time of construction.

Specific examples of off-site costs associated with chemical plants, complete refineries, and individual units which have been added to an existing refinery are presented in Table 1.

Table 1. Selected examples of off-site costs.

% of Battery Limits

	Chemical Plants					Complete Refineries				Units Added to Existing Refinery				
Plant No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Utilities	25	11	—	—	7	53	51	38	—	—	15	13	19	14
Storage	16	25	—	—	17	(A)	36	20	—	—	6	13	6	11
Buildings	0	0	—	—	13	28	11	5	—	—	0	0	0	0
Other	25	5	—	—	13	104	16	41	—	—	1	3	2	8
Total	66	41	46	27	50	185	114	104	130	33	22	29	27	33

Plant identification.

1. Reaction between light hydrocarbon and heavy chemical.
2. Ammonia from catalytic reformer hydrogen (added to existing plant).
3. Aromatic alkylation (new plant).
4. Aromatic alkylation (added to existing plant).
5. Organic and inorganic chemicals (added to existing plant).
6. Average of several foreign refineries.

7,8,9. U.S. Refineries, complete with dock facilities.

10. Fluid coker.
11. Catalytic reforming and solvent extraction installed at same time.
12. Vacuum crude still, fluid catalyst cracker and stabilizer installed at same time.
13. Butane fractionator.
14. Catalytic reformer.

(A) *Included in "other."*

Both the total and the individual items show a considerable variation. In general, it appears that the off-site costs associated with chemical plants (around 45%) are somewhat higher than those required by refinery process units (about 30%) where each is being added to an existing plant.

An example of a breakdown of a complete refinery located on deep water is presented in Table 2 (plant No. 7 in Table 1). Utilities account for the largest portion of the off-site costs while storage facilities are second.

The following information is offered to permit a rapid estimate of off-site costs where there are a large number of factors to be considered. This will also serve as a check list so that an estimator does not overlook vital off-site items. In most cases, a project under consideration will include only a portion of these items; however, over a period of time most of these items will probably have been covered at least once. Utilities and storage facilities will be included in almost each estimate. The cost of each item covered is adjusted to January, 1960.

Steam and power off-site costs

Costs of steam and power generation are an important part of over-all plant costs.

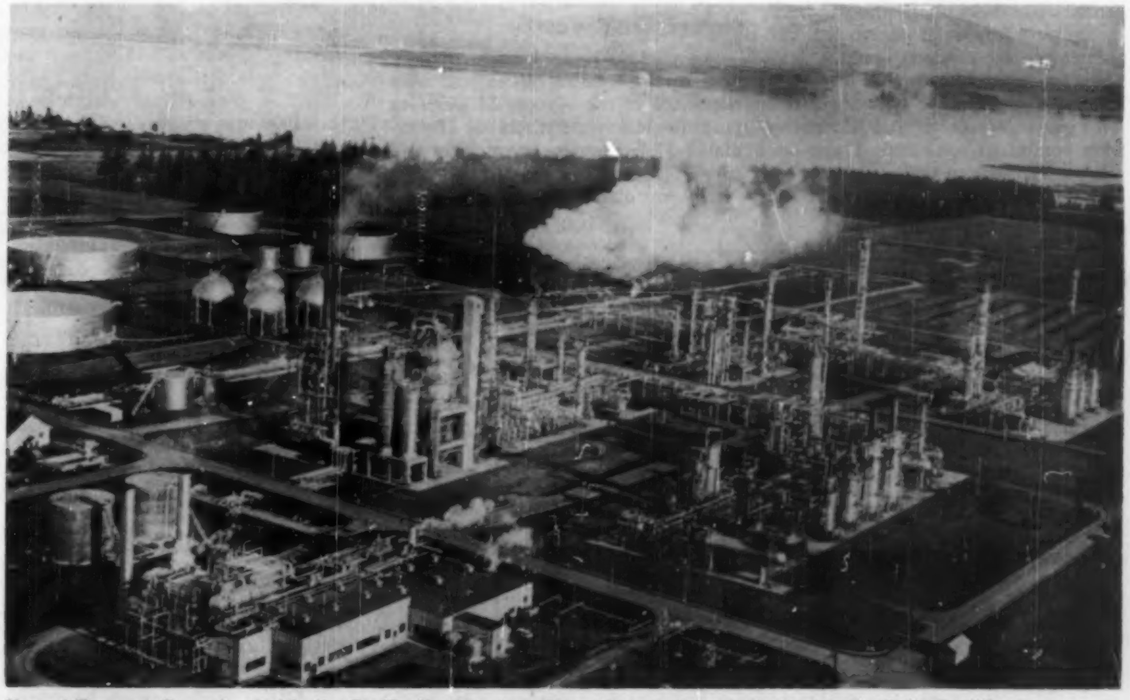
Steam generation facilities. Data presented in the literature vary widely and often are incomplete regarding steam pressure, inclusion of distribution facilities, etc. Published data were corrected to a constant 200 lb./sq. in. gauge steam pressure and are shown in Figure 2. Correction factors for other pressures may be obtained from Figure 3. The costs shown are for oil or gas-fired boilers. Coal-fired boilers can cost up to 20% more.

It may be seen from Figure 2 that the published costs of steam plants are considerably lower than costs based on actual experience. Part of this difference may be accounted for by the inclusion of distribution facilities normally encountered in actual experience. The rest of the difference may be because steam generation facilities are often installed simultaneously with power generation facilities and it is difficult to correlate each cost separately.

The variability between steam plant costs of a given capacity was found to be fairly large and as a result bands, instead of lines, were presented in Figure 2 to give some measure of the spread between costs.

Relatively small packaged steam generation facilities are available with capacities ranging from about 5 to 60 M lb./hr. The main advantages for these packaged units are flexibility and reduced costs. Watertube units can be provided at pressures up to 900 lb./sq. in. gauge. In general, the costs for packaged units are less than those for field-erected units due primarily to lower foundation and piping costs. Also, the automatic control system is normally simpler. The delivered cost of a 20,000 lb./hr. steam unit is about $46,000 excluding buildings, water treating facilities, stacks, and outside piping.

Correlations covering the costs of various types of field-erected steam generation units (*4*) and useful charts for pre-design cost estimating of boiler plants and steam-electric power plants with particular reference to location (*5*) are available.



Newest Texaco refinery located in the Pacific Northwest on Puget Sound shows both plant and off-site facilities.

Power generation. The cost of power generation and distribution is presented in Figure 4. The complete power plant cost includes generation, substations, transformers, and distribution facilities. The cost of steam generation required by the power plant is not included and its cost can be arrived at from Figure 2 once the steam requirement is established. In this regard, a recently built 15,500-kw. power generator required 420 M lb./hr. steam when operating on a supply of 900 lb./sq. in. gauge steam and holding a 150 lb./sq. in. gauge back-pressure on the turbine drive. The cost of a complete power plant of about 10,000 kw. capacity is about $2,500,000 ($250/kw.).

If purchased power is to be used, then only the transformers, substations, and distribution facilities need be provided. The cost of these is shown in the lower curve of Figure 4. The cost of power distribution facilities where a unit is being added to an existing refinery will range normally between $45 and $55/kw., while the cost for a complete grass-roots refinery may be as high as $60/kw.

Jacobs and Wilson (*6*) presented a paper on the economics of power generation and distribution useful to the estimator.

Cooling towers. Costs for cooling towers range considerably as indicated by the dashed lines in Figure 5. They are influenced greatly by the wet bulb temperature, the approach to the wet bulb temperature upon cooling, and the cooling range. The cost ranges from about $0.17 to $0.50/gal./hr., with an average of about $0.28 at the base conditions indicated. There appears to be little economy of size.

General descriptions of the basic types of cooling towers, design considerations, and cost information have been published (*7, 8*).

Water Treating and Distribution. The total cost for these facilities includes the costs of cooling towers, river or well intake and filtering, water treating, and distribution facilities. The cost of cooling towers is presented in Figure 5; the cost of each of the other items is presented in Figure 6.

To illustrate a calculation of the total cost of water, assume total cooling water requirements are 2040 M gal./hr. and that 306 M gal./hr. is once-through and make-up water of which 100 M gal./hr. requires treatment. The cost is then:

2040 M gal./hr. cooling tower (Figure 5):	$580,000
306 M gal./hr. river intake and filtering (Figure 6):	$58,000
100 M gal./hr. water treating (ion exchange, Figure 6):	$220,000
2040 M gal./hr. distribution (Figure 6):	$210,000
Total	$1,068,000

Thus, the cost of cooling towers may amount to about 50% of the total cost of the water treating and distribution facility. If no water treating facilities are needed then this figure would be closer to 70%.

Storage facilities costs

Storage facilities constitute a major item in the over-all offsite cost with over 90% of the storage cost due to tanks (including distribution). The remaining costs are for warehouses and storehouses.

The cost of storage tanks, less foundations are shown in Figure 7. The more common cone roof type is the least expensive, while mined underground caverns are the most expensive. Cone roof ranks in the 100,000 bbl. class cost about $1.10/bbl., com-

Table 2. Complete refinery breakdown.

A. Process Units	% of Each Category	% of Process Battery Limits
Distillation		21
Cracking and reforming		57
Solvent refining		8
Polymerization		10
Treating		4
Total		100
B. Offsites		
1. Utilities		
Steam[1],		
generation	26	
distribution	14	
boiler feed water	6	
Power,		
generation	20	
distribution	7	
Water,		
pumphouse and tanks	9	
cooling towers	12	
Gas and air distribution	1	
Waste disposal,		
gas	2	
oil	3	
Total	100	31
2. Storage		
Tanks proper	60	
Pipelines and loading racks	31	
Pumphouse	5	
Storehouses	4	
Total	100	36
3. Buildings		
Main office	30	
Shops[2]	36	
Laboratory	13	
Cafeteria	4	
Employee bldg.	12	
Miscellaneous[3]	5	
Total	100	11
4. Other		
Fire fighting	9	
Docks and shipping facilities	50	
Railroad tracks and equip.	6	
Roads, walks, and fences	14	
Sewers and drains	18	
Autos and trucks	3	
Total	100	16
5. Grand total off-sites		114

[1] *Includes lines and tanks associated with the steam plant.*
[2] *Machine, carpenter, welding, instrument, boiler, paint, blacksmith, and car shops.*
[3] *First aid, foreman, gatehouse.*

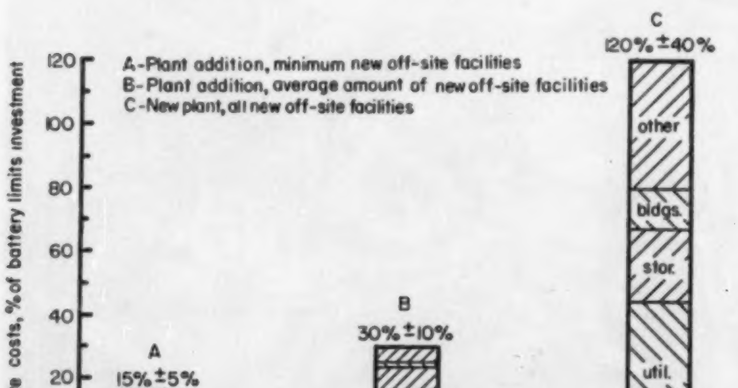


Figure 1. Summary of off-site cost percentages for both old and new plants.

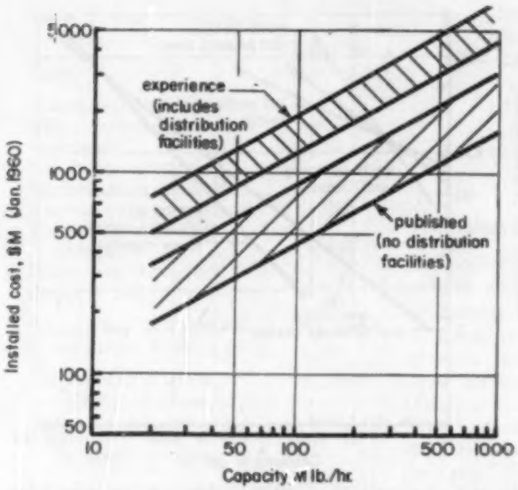


Figure 2. Installed steam generation costs for 200 lb./sq. in. gauge steam complete with boiler, instruments, buildings, water treatment, fans, and piping.

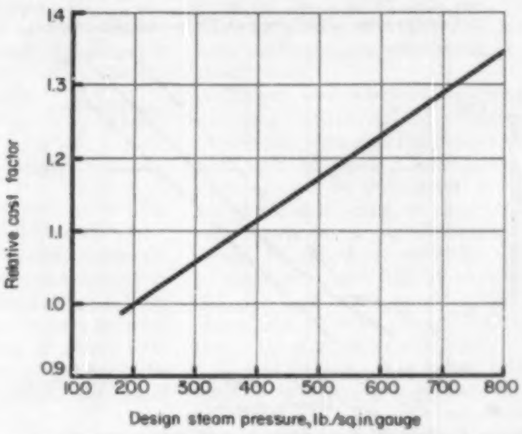


Figure 3. Effect of pressure on cost of steam plants.

pared with floating roof tanks at about $1.60/bbl. Floating roof tanks are normally employed for conservation measures, such as the prevention of loss through evaporation. Thus, it becomes an economic balance between the added expense of the floating roof tank and the value of the material which might otherwise be lost with a cone roof tank.

The size of storage facilities is dependent on the variability of supply and demand as well as contingency factors for unforeseen shutdowns. In many small refineries that encounter erratic and indefinite delivery, crude storage may be as high as 20-30 days. Product storage volume may be even higher, although smaller tanks are usually employed. It is not unusual to find 2 or 3 small tanks for each product to allow for receiving in one while pumping from or settling in another.

Salt domes in the Gulf Coast area are used extensively for the storage of butanes and propanes. The cost is in the range of $2.50/bbl., compared with about $8.00/bbl. for mined underground storage.

Highly volatile materials, such as propanes and butanes, are also stored above ground in steel spheres. Published data on spheres show the cost to range from about $10/bbl. for 15 lb./sq. in. gauge storage up to about $25/bbl. for 100 lb./sq. in. gauge. However, actual experience has indicated the cost to be about 20% less than the published cost. Spheres should be considered only where the volume to be stored is small or where underground storage is not feasible.

Foundation costs vary considerably between locations. The following approximate costs may be added to the tank cost presented in Figure 7:

Foundations	
Earth bearing	$0.35/sq. ft.
Pile bearing	
concrete piles and slabs	$8.40/sq. ft.
wood piles and slabs	$5.40/sq. ft.
Levees	
Fill dirt	$1.00/cu. yd.
Handling and forming	$0.55/cu. yd.

Additional cost data, descriptive information on types of storage tanks, the economic retirement age of tanks, and methods of calculating tank painting costs are available (9).

Buildings, land, and facilities

The cost of buildings is generally a significant portion of the over-all offsite cost for a completely new plant. In units where the addition of laboratories, warehouses, office buildings, gatehouses are not required, the cost of buildings is insignificant.

Costs for various buildings are listed in Table 3. Data on the cost of buildings vary over a wide range and the figures shown are those approximating the mean of all data reviewed. It is seen that the cost of some buildings

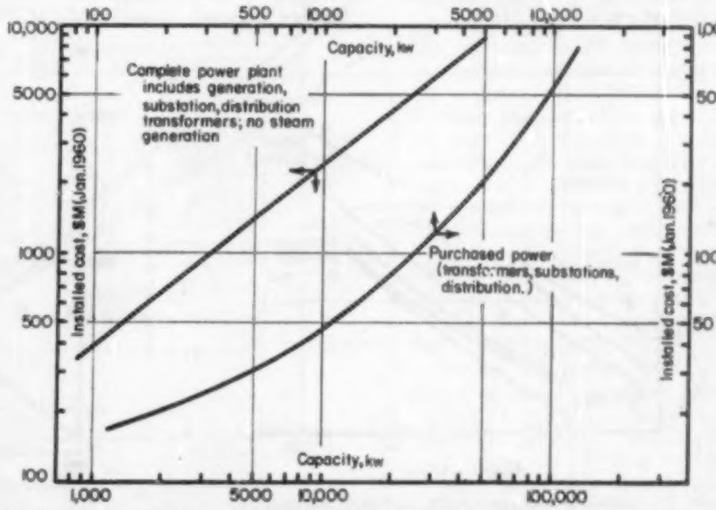


Figure 4. Installed power generation and distribution costs for both complete power plants (excluding cost of steam generation) and purchased power.

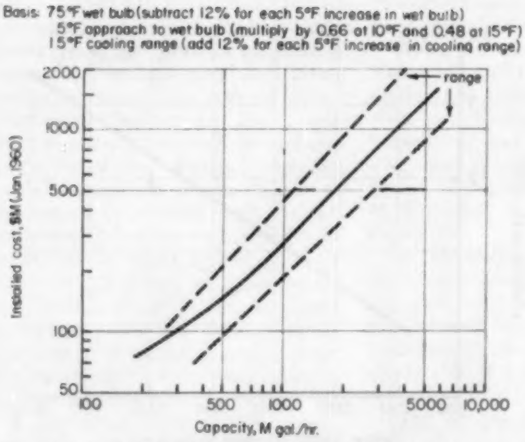


Figure 5. Cost of cooling towers including basin, foundation, pumps, motors, electrical, and instrumentation. Distribution facilities (pipelines, supports, etc.) are about 32% of base curves.

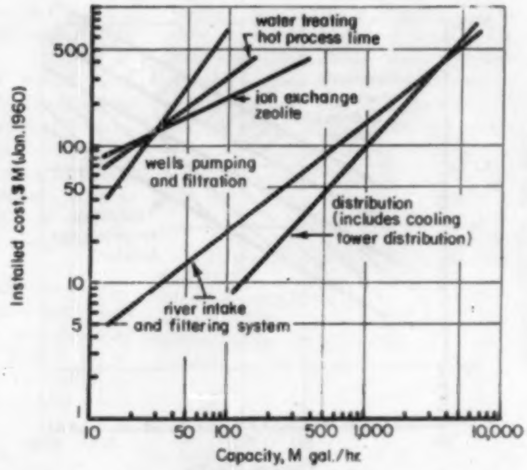


Figure 6. Water treating and distribution costs. Total cost for complete plant is equal to: (1) cooling tower costs (Figure 5), (2) river or well intake and filtering, (3) water treating, and (4) distribution.

is quite high when the cost of equipment is included. It would not be unusual in some specific circumstances to find costs varying as much as ±40% of those shown.

Periodic publication of costs of buildings (*10*) and complete details on warehouse estimation (*11*) are available.

Land. Prices of land vary considerably depending upon the location. The following ranges of costs are typical of current land values:

Rural	$200-400/acre
Rural, semi-industrial	$500-1500/acre
Industrial	$1500-9000/acre

More accurate cost data will have to be obtained by checking the local situation at each plant site.

Docks and wharfs. New dock facilities are often encountered, particularly when building a new plant. Modern dock facilities constructed of concrete and steel currently cost about $4,800 per linear foot where the deck is about 100 ft. wide. This includes all piping, roadways, and a moderate amount of dredging costs. In contrast, an all-wood wharf may cost $500-$2,000 per linear foot.

Fire protection. It is difficult to express the cost of fire protection equipment in any detail. However, the following percentages of battery limits investment may be used for rough approximation of these costs: 0.7% for small addition to existing plants, 2.0% for completely new installations.

Sewage disposal. Considerable advances have been made in the last ten years in the area of preventing and decreasing water contamination and pollution. Almost without exception every new plant today either is connected with an existing disposal plant or a new one is installed as a result of the new operation. The cost of sewage disposal plants is shown in Figure 8. As indicated, the cost of large capacity disposal plants can easily exceed $1,000,000. This includes a complete plant with flocculation, sludge removal, filtration, and incineration facilities. In addition, the costs for drainage, sewers, and traps leading to the sewage plant can be expensive. For example, these costs for a 50,000 bbl./day refinery range from $1,100,000 to about $1,500,000.

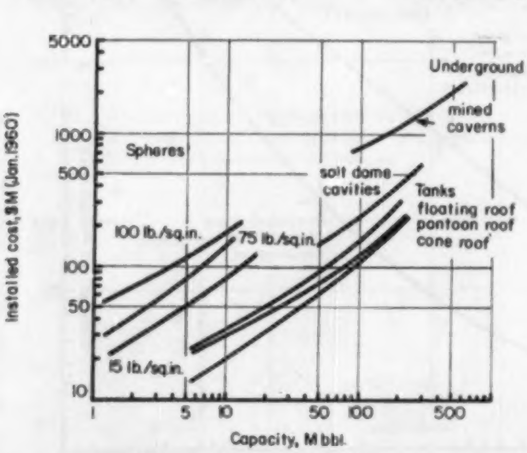


Figure 7. Installed storage costs without foundation. Foundation cost for 100,000 bbl. storage tank is about $6000, for other sizes apply 0.6 factor.

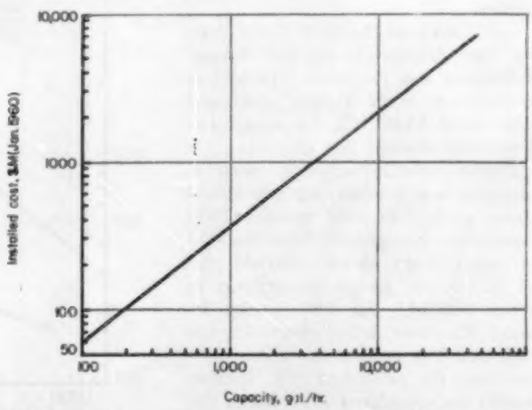


Figure 8. Sewage disposal plant costs including flocculation, sludge removal, filtration, and incineration.

Table 3. Cost of buildings.

Type	Jan., 1960 cost, $/sq. ft.
Manufacturing, multistory	21
Office, including furniture	35
Warehouse	10
Laboratory, equipped	58
Machine shop, equipped	53[A]
Carpenter shop, equipped	46[B]
Instrument and electric shops, equipped	49[C]
Paint shop, equipped	57[D]
Pump or compressor house	23[E]

[A] *Equipment is about 40% of total; building height is about 26 ft.*

[B] *Equipment is about 20% of total; building height is about 12 ft.*

[C] *Equipment is about 25% of total; building height is about 12 ft.*

[D] *Equipment is about 6% of total; building height is about 12 ft.*

[E] *Equivalent to about $20/driver horsepower; 12 ft. high steel frame, corrugated asbestos siding and roof, concrete foundation, utilities and plumbing.*

Roadways. Roadway costs vary considerably due to both differences between materials of construction and the terrain involved. The following costs are typical of some recent installations:

	sub. base, in.	cost/ sq. yd.
Asphalt paving		
3 in.	12	$5.50
1.5 in.	6	$2.90
Concrete paving		
4 in. slab mesh reinforced	6	$6.32
6 in. slab mesh reinforced	6	$7.36
8 in. slab mesh reinforced	6	$8.45
10 in. slab mesh reinforced	6	$9.44
12 in. slab mesh reinforced	6	$11.45

Transportation facilities

Another important cost to be considered are transportation facilities.

Railway tracks. It is often necessary to install new spur tracks adjacent to the unit being installed. The cost for spur trackage varies between $15 and $22/ft., with a mean of about $19. This includes the cost of grading, ballast, ties, tracks, switches, and small bridges.

Railway tank cars. Railway tank cars are almost always rented, rather than purchased. The pertinent factors controlling the purchase are the relative value and availability of money and the desire to completely control the tank car. Typical current prices for tank cars constructed of various materials are listed below:

	8000 gal.	10,000 gal.
Steel (standard)	$10,250	$10,750
Aluminum	....	$16,500
Stainless Steel	$23-30,000	$30-40,000

These costs do not include steam coils; they can be added to the standard steel cars for about $1,250.

Loading racks. Railway loading racks are frequently installed in conjunction with a new plant or unit. A typical cost is $15,000 for a loading rack which will accommodate four tank cars. This includes all necessary piping at the loading rack site, flexibility to handle three different products, and a single railway track of about 140 ft.

Tankers and barges. Occasionally sea-going tankers will be required in connection with the installation of a new unit or plant. These may be either leased or purchased. If they are purchased, then a considerable sum of investment capital must be secured. Supertankers currently range in size from about 350 M to 400 M bbl. and cost in the neighborhood of about $14-17 MM. A 250,000 bbl. tanker costs about $10-12 MM.

Barges traveling over inland waterways have carrying capacities of up to 20,000 bbl. The cost may range from $13.50 to $15/bbl. for vessels in the 18,500 to 12,000 bbl. capacity range.

Gas compressor stations

A summary of published (*12, 13*) and private cost information for gas compressor stations is shown in Figure 9. In general reciprocating compressor stations cost more than centrifugal stations with the exception of the centrifugal station employing gas-engine drive. Electric-motor drives are normally less expensive than other drives. There is a wide variation in the cost of compressor stations of a given type due to variations in design, location, and number of units combined to reach the desired capacity. As a result, the reliability of the data summarized here is no better than ±25%.

Complete packaged compressor units can be purchased; these usually have ratings up to about 660 hp. They generally cost in the order of $200/hp, whereas a field-erected permanent compressor station of the same capacity might cost from 50 to 100% more.

Plant pipelines. The cost of steam or water and field lines can be estimated from Figure 10. These costs vary about ±50% for a given type line as a result of the particular circumstances surrounding each installation (such as: congested vs. free area, weather conditions, soil conditions, labor rates, and efficiency).

The costs of plant pipeline material are shown in Figure 11.

Mobile equipment costs. Certain types of mobile equipment such as trucks, bulldozers, draglines, and hoists are sometimes necessary to the unit operation. A few typical examples of mobile equipment are given below.

Rider-type, counter-balanced fork-

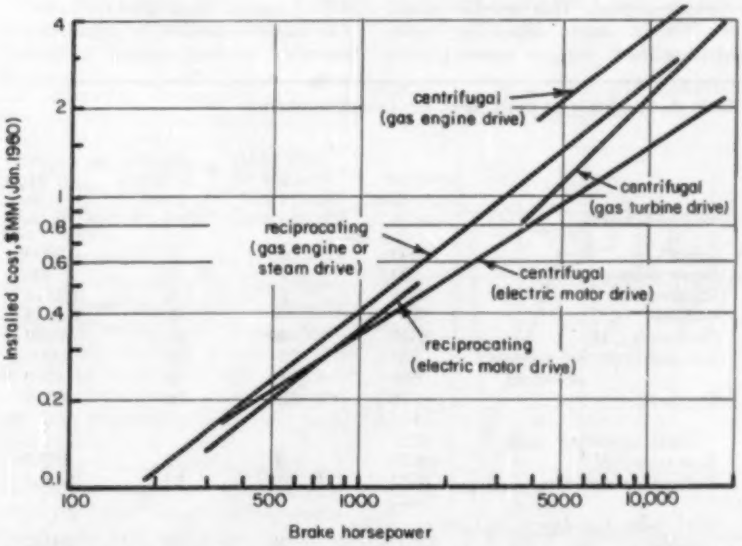


Figure 9. Cost of complete compressor stations including land, equipment and construction expenses. Packaged compressor units may cost 1/3 less.

lift trucks of about two tons capacity cost in the order of $6,000 with an internal combustion engine and about $8,000 for the electric-powered style. Corresponding costs for five tons capacity are about $9,700 and $12,000. The battery charger required for the electric-powered truck may cost in the order of $2,000.

"Dumpster" type trucks used for hauling bulk chemicals, liquids, or solids, cost in the order of $16,000 for a complete outfit.

A gasoline- or diesel-powered, five-ton capacity mobile crane costs around $11,000. A 35-ton hoist including clamshell bucket costs about $60,000. The cost of a similar 10-ton rig is about $20,000. Complete description and cost data for various power shovels, hoes, cranes, draglines, etc. are available (*14*).

Tank trailers are sometimes required for hauling chemicals associated with a unit operation. Typical costs for 4300-gal. unlined tanks are:

Carbon Steel	$6,800
Aluminum	11,000
Stainless Steel	14,000

These costs are for the tanks alone, excluding the truck chassis, which may cost in the order of $5-6,000

It is becoming customary to rent rather than buy much of the equipment discussed above. Recent information on construction equipment rental rates (*15*) are available.

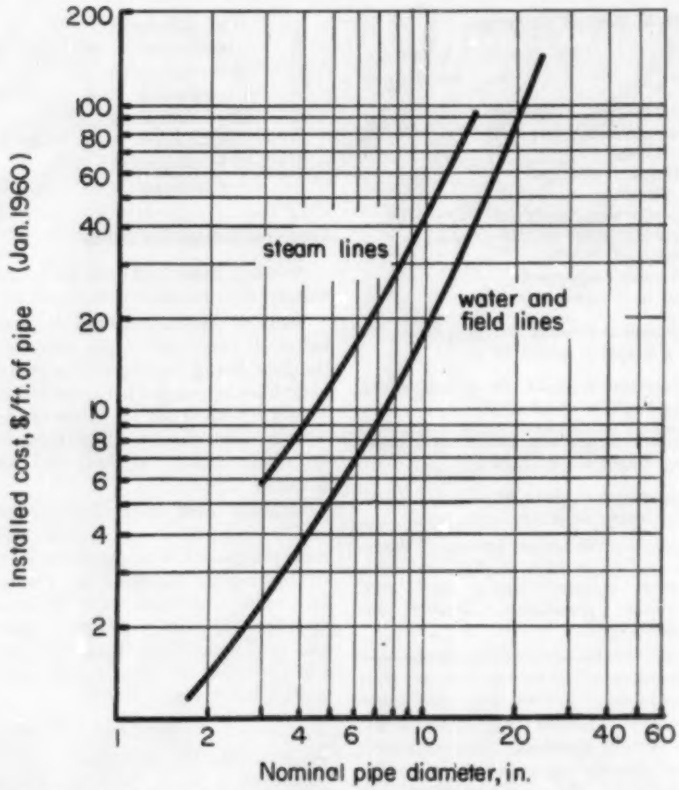


Figure 10. Installed costs of plant pipelines including installation, supports, valves, and fittings. Cost of steam lines also includes insulation.

Working capital

Working capital is much easier to describe than it is to estimate, yet it cannot be neglected in a sound capital cost analysis. It is commonly defined as the operating capital which must be provided by the company to support process inventories and pay its bills.

Working capital includes the value of raw materials stocks, in-process and product inventories, operating and maintenance supplies, credit extended and obtained, and funds required for the payment of manufacturing expenses. Net profit and depreciation reserve are assumed to be turned over to management on receipt for immediate use, and therefore they are not considered in the project's working capital analysis.

The estimation of working capital is presented on two bases. The first is the order-of-magnitude estimate based on a percentage of sales and the second is a more definitive estimate where each item that affects working capital is considered in detail by a cash flow analysis.

Order-of-magnitude estimate. In a rough order-of-magnitude estimate, working capital is best developed as a percentage of sales based on company experience with similar processes. Petroleum and chemical operations require about 10-25% of annual sales as working capital. This number could be 30% or more depending upon whether there are any unusual items present such as expensive catalyst inventory or expected long delays in getting on stream, etc.

Working capital for an addition to an existing plant would be considerably lower and in the range of 1 to 10% of annual final product sales.

Definitive estimate. A definitive estimate of working capital is elusive

Table 4. Summary of cash flows for sample problem.

Operating costs	Cost per calendar week, $	Time from startup to first cash flow, weeks	Avg. period between cash flows, weeks	Amount of each cash flow $
Labor	2000	0	1	2000
Supervision	200	1	2	400
Maintenance	1538	2	3	4614
Utilities	1385	5	6	8310
Chemicals	2308	19	20	46160
Ins. and taxes, Ad valorem	385	25	26	10000
personnel	635	1	2	1270
Overhead	776	12	13	10100
Total operating costs	9227			
Raw materials	44073	3	1	48762[A]
Federal income tax	8327	22	13	108250
Prod. value (ex deprec. and net profit)	61627	6	1	68182[A]

[A] *Based on 47 operating weeks per year.*

because it is not really a fixed quantity, but is in a state of fluctuation as a result of the manner in which business is transacted. The amount of working capital required over the life of the project changes with changes in sales volume, sales price, credit terms, inventory levels, wages, and other expenses. If the product is subject to seasonal demands, the working capital must be high while inventories are being built up in preparation for the demand, then low after the seasonal demands are met. Working capital is usually higher just after start-up since the project must be carried along until sales dollars begin to come in.

The cash balance maintained at any one time should be the minimum safe amount necessary to meet current expenses. To some extent this is a matter of judgment on the part of management.

Example of definitive estimate

The first thing that must be done in the definitive estimate of working capital is to establish the timing of cash and material flows. This is illustrated by a cash flow summary representing a fictitious process in Table 4. The following assumptions are made:

1. Production and raw materials rates are constant with no seasonal fluctuations.
2. All shipments and payments for materials are made weekly on 4-week credit terms.
3. In-process, operating, and maintenance supply inventories are negligible since these are intermediate storage items only. Raw material and finished product inventories are included.
4. Operating expenses start to accrue one week before start-up.
5. Initial raw material delivery occurs one week before start-up. Since credit terms are for four weeks, initial payment is made three weeks after start-up.
6. Payment for product is received six weeks after start-up. This allows product inventory to be built up to an average operating level of 1.5 weeks by delaying the first shipment until the second week after start-up. Payment for this shipment is not received until four weeks later in keeping with credit terms.
7. Cash flow for raw materials and product are based on 47 operating weeks per year. This allows five weeks per year for test and inspection, two weeks at mid-year and three weeks at end of year.

The above assumptions are not restrictions on the method of analysis and may be different for other problems.

With the information developed in Table 4 a realistic running analysis of all daily or weekly cash flows may be developed. These weekly flows are accumulated and plotted in Figure 12. This plot represents all working capital requirements over a period of 100 weeks. It contains the cash required to support all inventories and accounts receivable. Cash requirements are also included to meet running expenses when they come due. These cash requirements are appropriately reduced by income from product sales as it is received.

Working capital requirements up until the time of income is seen to be about $180,000. At this point anticipated start-up costs plus a contingency could be added. Assuming 20%, this would bring the initial cash requirement to the level indicated by the dotted line labeled "level *A*". These non-recurring start-up costs are not to be included in the cumulative working capital analysis itself, except as they may reduce profits and hence taxes. A discussion of start-up expenses for chemical plants is available (*16*).

To determine an average working capital requirement over the life of the project the point indicated by level *B* in Figure 12 might be chosen. This might be desirable in the case of

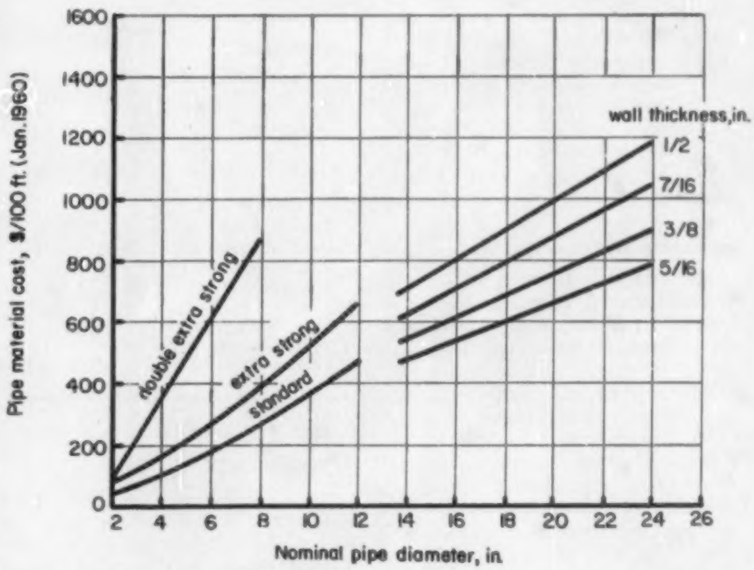


Figure 11. Cost of black pipe material (excludes freight or installation).

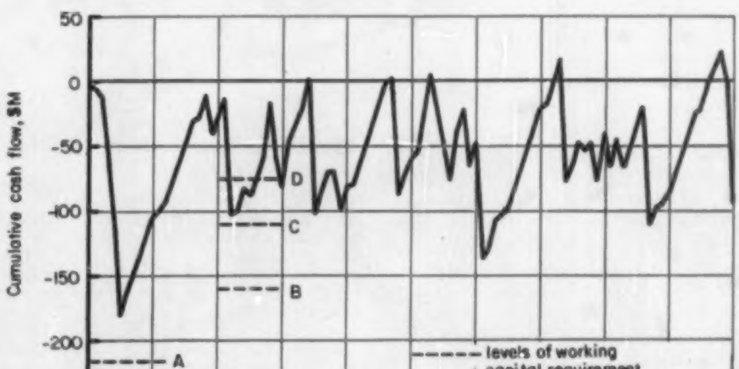


Figure 12. Cumulative working capital requirements for sample problem.

a small business where the project represents a large proportion of its operating budget and where no short term borrowing is desired. It is not an efficient utilization of funds. Levels *C* or *D* may be realistic levels, though not conservative, for an efficient operation when many other projects are operating simultaneously. The peaks in cash balance of one project may be used to satisfy the valleys of another. For evaluation purposes some consistent method might be selected. For example, the arithmetic average cash level could be calculated and a fixed percent of the maximum range added.

The literature on working capital is not extensive. Most authors suggest short cut procedures employing the more tangible elements such as average inventory values, accounts receivable, and cash to meet a certain time period of expenses. These methods may be subject to considerable error, since they neglect the manner in which taxes payable and accounts payable reduce working capital requirements. Weaver and Lyndall (*17, 18*) discuss the elements of working capital using the cash flow method.

Table 5. Effects of offsites and working capital on economic analysis.

	Process A			Process B	
	1 Battery limits invest. only	2 With offsites included	3 With off-sites and working capital	4 Battery limits invest. only	5 With off-sites and working capital
Capital Required:					
Battery Limits Investment	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000
Offsites	....	3,000,000	3,000,000	....	7,000,000
Working Capital	....	....	1,000,000	....	5,000,000
Cash Flow Analysis:	\$M/yr.	\$M/yr.	\$M/yr.	\$M/yr.	\$M/yr.
Product Sales	40,000	40,000	40,000	80,000	80,000
Costs:					
Raw Materials	25,000	25,000	25,000	60,000	60,000
Oper. Costs	9,250	9,250	9,250	13,250	13,250
Depreciation, 5%	750	900	900	750	1,100
Total	35,000	35,150	35,150	74,000	74,350
Gross Profit	5,000	4,850	4,850	6,000	5,650
Fed. Tax, 50%	2,500	2,425	2,425	3,000	2,825
Net Profit	2,500	2,425	2,425	3,000	2,825
Depreciation	750	900	900	750	1,100
Cash Flow Income	3,250	3,325	3,325	3,750	3,925
Profitability:					
Payout, Years[1]	4.6	5.4	5.4	4.0	5.6
Per Cent Return, %[2]	16.7	13.5	12.8	20.0	10.5
Interest Rate of Return, %[3]	19.2	16.4	15.5	22.1	12.9

[1]*Payout time, years = Total investment ÷ (Net profit + Deprec.).*
[2]*Per cent return = Net profit ÷ (Total investment + Working capital).*
[3]*As described in reference (19) using continuous discounting over a 20 year life.*

Summary and conclusions

Methods of estimating off-site investment and working capital are presented. It is definitely shown that these costs are often very large and should be a vital part of most profitability analyses. The use of percentage factors is recommended for quick order-of-magnitude estimates of off-site costs; specific factors to be used depend largely on whether the process considered is an addition to an existing plant or a brand new grass-roots plant. The costs of individual off-site facilities are presented for the purpose of arriving at more accurate estimates. Factors to be considered for working capital estimation are suggested; also a typical cash flow analysis of working capital is given.

Table 5 illustrates the effects of including off-sites and working capital in profitability analyses. Two processes to make different products are competing for investment capital. As off-sites and working capital are added in Process *A*, payout time is increased from 4.6 to 5.4 years, return on investment is decreased from 16.7 to 12.8%, and the interest rate of return is decreased from 19.2 to 15.5%.

The inclusion of these factors can also have a significant effect on the final choice between Processes *A* and *B*. For example, if they are excluded (Cases 1 and 4), Process *B* (Case 4) is the more attractive. However, if they are included (Cases 3 and 5), Process *A* (Case 3) is more attractive.

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LITERATURE CITED

1. Bauman, H. C., *Chem. Eng. Progr., 51*, 45J-50J (Jan., 1955).
2. Tielrooy, J., *Chem. Eng. Progr., 52*, 187-190 (May, 1956).
3. Jandrisevits, P., *Ind. Eng. Chem., 43*, 2299-2301 (Oct., 1951).
4. Prater, N. H., and D. W. Antonacci, *Petrol. Refiner, 38*, 243-246 (May, 1960).
5. Bishop, J. W., *Plant and Power Services Engineer, 8*, 20-22 (May, 1960).
6. Jacobs, D. L. E., and W. B. Wilson, *ASME Paper No. 59-A-330* (presented at Annual Meeting, Atlantic City, N J., Nov. 29-Dec. 4, 1959).
7. Prater, N. H. and D. W. Antonacci, *Petrol. Refiner, 38*, 119-124 (April, 1959).
8. Katell, S., and J. H. Faber., *Cost Eng. 2*, 70-76 (July, 1957).
9. Lynn, C. V., *Petrol. Processing, 10*, 361-365 (Mar., 1955).
10. *Anon, Eng. News Record, 159*, 288 (Oct. 17, 1957).
11. Sellers, A. R., *Chem. Eng., 67*, 151 (Feb. 22, 1960), *67*, 152 (Mar. 7, 1960).
12. Bromberg, I., *Petrol. Refiner, 37*, 225-226 (May, 1958).
13. Kinney, G., *Oil Gas. J., 58*, 100-114 (June 27, 1960).
14. Zimmerman, O. T., and I. Lavine, *Cost Eng., 3*, 68-84 (July, 1958).
15. Adams, C. A., *Chem. Eng., 67*, 146 (Feb. 8, 1960).
16. Bauman, H. C., *Ind. Eng. Chem., 52*, 51A-52A (March, 1960).
17. Weaver, J. B., and F. S. Lyndall, *Ind. Eng. Chem., 51*, 67A-68A (June, 1959).
18. Weaver, J. B., and F. S. Lyndall, *Ind. Eng. Chem., 51*, 49A-51A (August, 1959).
19. Weaver, J. B., and R. J. Reilly, *Chem. Eng. Progr., 52*, 405-412 (Oct., 1956).

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Techniques for evaluating petroleum processes

Use these techniques for estimating the operating costs of projected petroleum processes. Learn what cost items should be considered, and how each should be handled.

Other articles (5, 6) have discussed methods of estimating investment costs for process units and for off-site equipment. Here we show how these investment costs are used to predict the over-all economic outlook of proposed processes in the petroleum field. In compiling examples of operating costs and manufacturing economics for this article, however, it was necessary to use investment costs already available. Both investment and operating costs are presented only as examples; they should be accepted as such, and undue reliance should not be placed on the absolute value of the figures, even though they are characteristic of the processes used.

There are various ways of assembling operating costs, and of using them in an economic analysis of a projected operation. One of the problems in any technique is to make sure that all costs are taken into account. The right technique must be easily understood and must fit the experience of those for whom the analysis is prepared.

In this article the mechanics of operating cost estimating are discussed first. A review of the economic evaluation step follows, and finally, some discussion of short cuts for rough

The world's first commercial fluid coker (right) is 196-ft. unit at Carter Oil's Billings, Mont., refinery.

evaluations and projection-type economics is given. Two refining processes are used as examples of the application of these evaluation techniques to petroleum operations: Fluid Coking and Hydrofining.

Process descriptions

Although the estimation of refining process operation costs does not require a knowledge of what the processes do, it is convenient to have some understanding of them. Accordingly, Tables 1 and 2 briefly describe some of the technical data for fluid coking (1, 2) and hydrofining (3). Important operating requirements are tabulated. Figures 1 and 2 show simplified process flow sheets.

Fluid coking converts petroleum residues which cannot be processed economically in conventional cracking operations, upgrading them into distillate products and coke. The charge stock is fed to a fluidized solids reactor, and deposits additional coke on the finely divided coke used as circulating solids. This stream then flows to the burner, where part of the coke laid down is burned off to supply heat for the process. The distillate products and gas go overhead through a scrubber where entrained coke is removed, and thence to fractionating and light ends recovery equipment.

Hydrofining comprises a mild treatment of petroleum stocks with hydrogen. It is a fixed bed operation with relatively long periods on-stream before the catalyst must be replaced or regenerated. The operation ordinarily involves the consumption of little hydrogen. Make gas from a catalytic reformer may be used once-through to supply the necessary hydrogen.

Hydrofining may be applied to a wide variety of refinery streams, ranging from naphthas to light distillates, diesel fuels, cat feeds, and lubricating oils. As indicated in Table 2, the conditions vary widely, depending on the feed run and the product quality which must be obtained. For this article, hydrofining of a heating oil cut is used as an example.

Cost estimation mechanics

The principles involved in the build-up of operating cost items are discussed below. Table 3 shows the results of applying these principles to fluid coking and hydrofining. These are only illustrative and do not necessarily represent any particular situation. They are based on 10,000 and 12,000 bbl./stream day plants, respectively.

The investments used for the process units and for the various off-site items are shown. For this article, it is assumed that steam and electric power are purchased. Cooling water will normally be supplied by the refinery, and the investment cost for its supply and for the distribution of cooling water, steam, and power must be provided for. Quantities required are shown in Tables 1 and 2. Sufficient tankage must be provided to carry both feed and products over periods of shutdown, feed shortage, etc. However, neither one of the processes used as examples requires large amounts of feed, or product, storage associated with the process. For the purpose of this article, the tankage is taken in both examples at 20% of process unit investment.

Receiving and loading, including docks, are important cost items in any refinery. However, neither fluid coking nor hydrofining starts with crude nor ends with finished products, so this item is not properly charged against them. "Other off-sites" include the investment required to carry on the large number of other operations necessary to support the process units. These are discussed in the section on general "overheads." The investment in these off-sites in proportion to process unit investment varies widely. It will be more for a grass roots plant than where a new process is installed to complement or to replace an existing refining operation. In these examples, an increment requirement amounting to 35% of the process unit investment is used.

Table 1. Technical data—fluid coking.

Characteristic feed inspections (vacuum residuum)	
Gravity, °API	4
Conradson carbon, wt %	24
Ultimate yields on coker feed	
C_{3^-}, wt %	10
C_4/430°F. V.T. naphtha, vol %	23
430/1015°F. V.T. Gas oil, vol %	50
Coke (gross), wt %	29
Products quality	
Naphtha res. oct. No., clear	77
Gas oil gravity, °API	17
Utilities and fuel (10,000 B/SD[c] Unit)	
Steam, lb./hr.	(6000)[a]
Power, kw	150
Cooling water, gal./min.	3600
Fuel, million Btu/hr.[b]	125
Operating conditions	
Reactor temp., °F.	900-1050
Pressure	*ca.* atmospheric

[a] *Net steam producer*
[b] *Normally coke burned in the process*
[c] *Barrels per stream day*

Operating costs—direct expenses

The discussion below uses the identification numbers of Table 3. Similar listings of operating cost items have been compiled by Van Noy, *et al.* (4).

1. Operating labor requirements. The number of operators who must be on duty to assure satisfactory operation of the process unit can be determined by a step-by-step build-up. Unless this is done in considerable detail, it can be low. The number is frequently determined by conditions of stress rather than by normal operation. For rough evaluation, in large process units one operator on duty/-$1 million of process unit investment is often a satisfactory guide. This will give too low a figure for small or complicated units. It is not good practice for an operator to work alone, but two or more operators may operate two plants where physical proximity allows it. In staffing the fluid coker, three operators on duty are specified for a process unit investment of $2.3 million; for the hydrofiner one man is specified for a $1.0 million process investment, on the assumption that others would be available to help. Pay rate is $3/hr.

2. Supervision and other labor. Supervision at the site includes shift foremen and plant superintendents. For a large operation, this is often projected at 10% of operating labor. Other labor, clerical and janitors, etc., not properly repair labor, can go as high as another 10%. These figures are variable and it is perhaps best to

Table 2. Technical data—hydrofining.

Characteristic feed inspections (heating oil)	
Boiling range, °F	360/655
Sulfur, wt %	0.92
Copper number	92.0
Carbon residue (10% btms.)	0.03
Color, Tag Robinson	17
Product quality	
Sulfur, wt %	0.77
Copper number	$<$1.0
Carbon residue (10% btms.)	0.02
Color, Tag Robinson	21
Utilities and fuel (12,000 B/SD[a] unit)	
Steam, lb./hr.	7,500
Power, kw	300
Cooling water, gal./min.	3,800
Direct fuel, million Btu/hr.	60
Operating conditions for hydrofining	
Temp., °F	400-800
Pressure, lb./sq.in.ga.	50-800
Feed rate, vol./hr./vol.	0.5 to $>$16
Hydrogen circulation, SCF/bbl.	up to 3500

[a] *Barrels per stream day*

take the sum as between 10 and 20% of operating labor.

3. **Maintenance.** Repair labor is separated from total repair costs for convenience in calculating payroll overhead. Overall maintenance rates as an annual percent on investment vary widely, from the order of 1% for power plants, to 10% or more for high temperature, corrosive process units. A 1.5-2.0 to 1.0 ratio for labor to material is not unusual. In Table 3, maintenance figures are calculated on the basis of the investment in the process unit, plus off-sites not cared for in their own cost, i.e., all except utilities generation. Since off-sites will generally have lower maintenance percentages, this inclusion reduces the over-all ratio. Accordingly, a figure of 3% on process unit plus off-sites investment (excluding steam and power supply) is used for direct maintenance labor, and 2% on the same basis for maintenance material.

Table 3. Build-up of operating costs.

	10,000 B/SD[a] Fluid Coking	12,000 B/SD[a] Hydrofining
Investments		
1) Process unit	$2,300,000	$1,000,000
2) Steam and power	(purchased)	(purchased)
3) Water; utils. distr'n.	150,000	200,000
4) Tankage	450,000	200,000
5) Docks, receiving, loading	—	—
6) Other off-sites	800,000	350,000
7) Total	$3,700,000	$1,750,000
Operating Costs, per calendar day		
Direct expenses		
1) Operating labor	$216	$ 72
2) Supervision and other labor	34	12
3) Maintenance labor	305	141
4) Payroll overhead	110	45
5) Operating supplies	25	15
6) Maintenance materials	200	95
7) Purchased utilities	25	135
8) Water	50	50
9) Fuel	—	265
10) Catalyst and chemicals	—	10
11) Total Direct	$965	$840
Indirect expenses		
12) Gen'l. and adm. overhead	390	170
13) Royalty	450	215
14) Local taxes, insurance	100	50
15) Total Cost, ex-Deprec'n.	$1905	$1275
Same, per barrel[b]	21.2¢	11.8¢
Same, per year	$700,000	$465,000

[a] *Barrels per stream day*
[b] *90% Service Factor*

4. **Payroll overhead.** This includes the additions to employee payroll which are directly related to the size of the payroll: bonuses, vacation allowance, jury duty, social security, pensions, disability and sickness costs, liability insurance, workmen's compensation, etc. The size of this addition varies widely and in any estimate must be related to the experience of the plant where the process is to be installed. As an example, a figure of 20% of the payroll (Items 1, 2, and 3) is used.

5. **Operating supplies.** These are normally small but are frequently taken as high as 20% of maintenance material. This is a housekeeping item. It should include normal servicing supplies: lube oils, greases, process unit office supplies and incidentals, etc.

6. **Maintenance material.** See the discussion of Item 3.

7. **Purchased utilities.** Although steam and power were formerly pro-

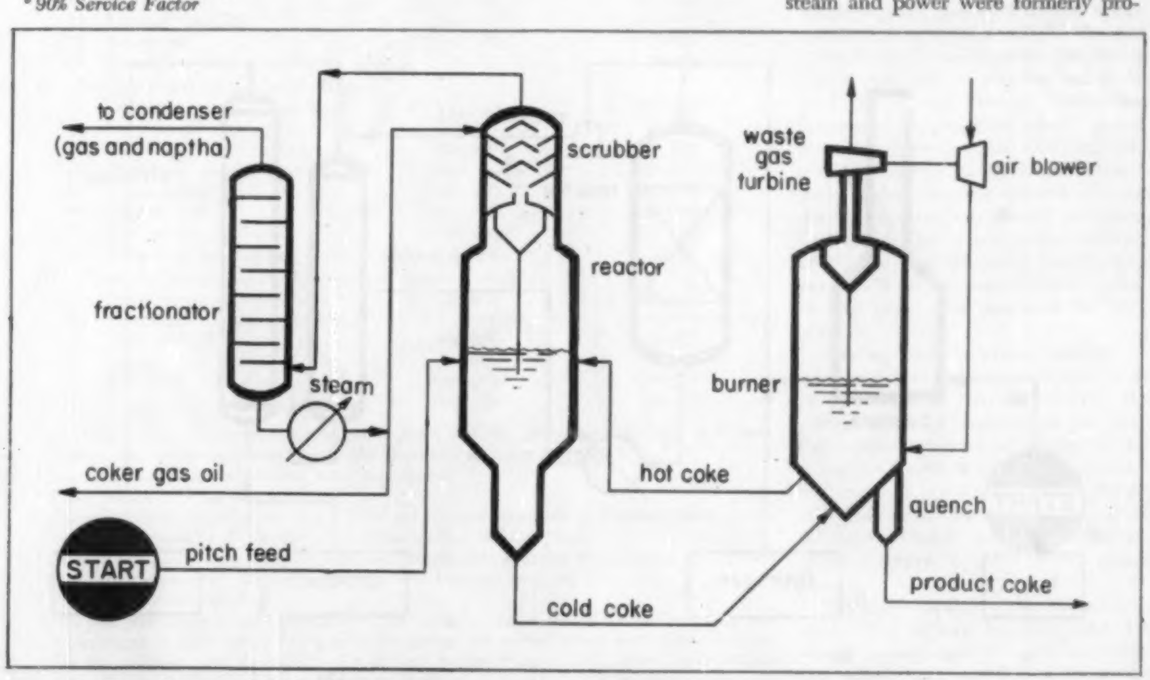

Figure 1. Flow diagram of fluid coking process.

duced as part of the refinery's operations, practice in recent years has tended to their purchase from the local public utility. The utility has a wide range of customers, it is normally limited by regulatory bodies to overall earnings of 6-7%, and its capitalization includes a higher ratio of low interest bonded indebtedness than does an oil company's. Consequently, the saving in using this source is significant. For the examples of Table 3, the costs of power and steam at the refinery limits are taken at 0.8¢/kw-hr and 50¢/1000 lb. respectively, based on the requirements of Tables 1 and 2.

The cost of steam and power distribution within the refinery must be provided for. This is primarily in investment and maintenance costs, since little direct operating cost is involved. For this reason, allowance for investment in distribution of steam and power is shown as one of the off-site investment items. If utilities are generated by the refinery, each utility should include the necessary allowance for maintenance, depreciation, taxes, and insurance in the intra-refinery charges.

8. Cooling water. Cost of operating the river water pumping or cooling tower system (or the like) excluding maintenance and depreciation, should be allowed for in the unit charge. For the examples in Table 3, a figure of 1¢/1000 gal. is used.

9. Fuel. Direct fuel required by the process must be allowed for at competitive rates. In the hydrofining example, the relatively low rate of 20¢/million Btu is employed. In fluid coking, the coke itself provides sufficient fuel. While it is normal practice to include utility fuel costs in utility prices, it is sometimes useful to combine all fuel requirements, including those for raising steam and power, into a single factor so that the overall effect of fuel price can be seen directly.

In establishing daily costs, fuel and utilities requirements must be adjusted for the ratio of stated capacity at which the plant operates over a long period of time—the service factor. In these examples a service factor of 90% is used, and the calendar day throughout is 0.9 of the stated, stream day capacity. Cost items handled prior to this group are normally not affected by service factor.

10. Catalyst and chemicals. Catalytic processing has become so popular in refining that catalyst cost is now a standard item. However, many processes still use no catalyst. This is the case with fluid coking. With hydrofining, catalyst is required and the allowance of 0.1¢/bbl. of feed covers catalyst requirement calculated at a price of about $1/lb. This is calculated from a knowledge of the oil rate/lb. of catalyst and its expected life, both of which must be determined from test work on the process. Provision for other "chemicals" would include the cost of acid, caustic, or doctor solution, where needed. If consumption of hydrogen in the hydrofining example were significant, its cost would be included here.

Table 4. Operating costs covered in general overhead expenses.

1. Roads and sewers
2. Storage and tankage
3. In-plant transportation and movement of materials and equipment
4. Shop (mechanical, pipefitting, electrical, carpentry, etc.) overhead, not directly chargeable to maintenance
5. Storehouse, including spare parts handling (investment for spare parts inventory should be in off-site investment)
6. Plant protection, guards, etc.
7. Refinery air; other minor utility-type items
8. Non-process utility requirements
9. Waste disposal, oil loss control
10. Inspection and testing laboratory
11. Technical service
12. General engineering and maintenance
13. Medical, hospital and first aid
14. Safety and fire prevention
15. Industrial and employee relations expenses, including employee training
16. Public relations expenses
17. Other operating expenses associated with off-site investments not covered in charges for utilities, etc.

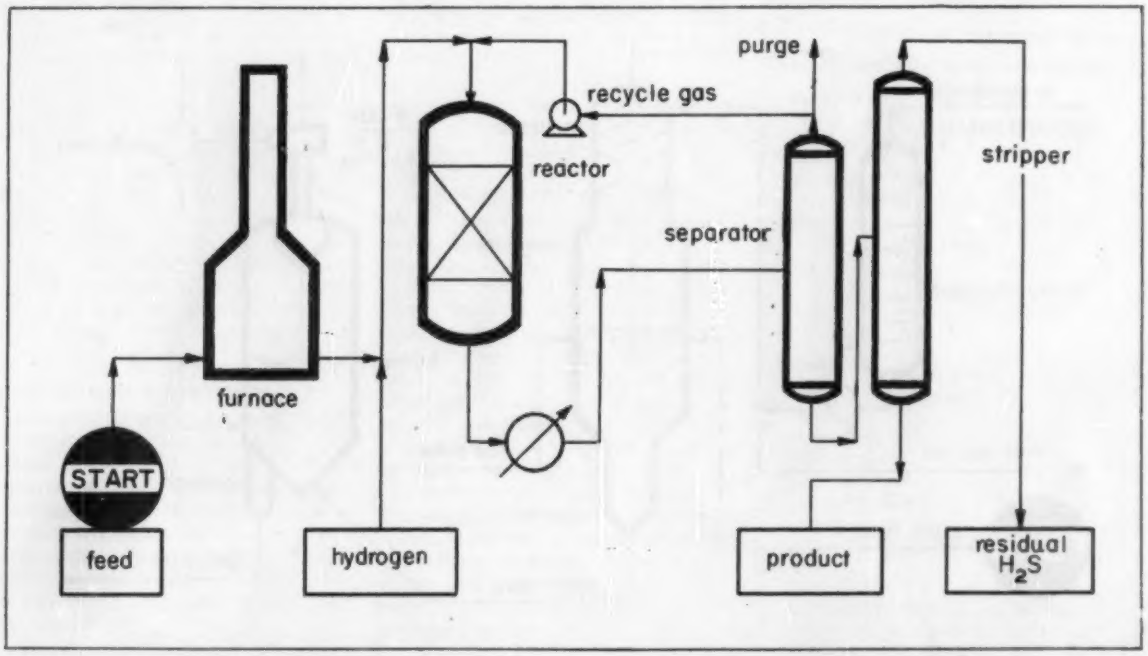

Figure 2. Flow diagram of a hydrofining operation.

11. Total direct costs. The sum of the preceding 10 items comprises the total direct cost. If the plant is not operated, these costs are not incurred.

Operating costs— indirect expenses

There are other costs which must be charged against the process under consideration, but which have no direct relation to whether the process is operated or not. These include general and administrative overheads, largely related to operation of the off-site investments, excluding utilities. Taxes are also assessed against the plant, whether it operates or not. Administrative costs are normally considered as a continuing and constant charge against the plant, although some companies prefer to charge them on a unit output basis. Royalties and process licensing costs are usually included in indirect costs. Depreciation is a part of total operating costs, but is discussed here in the economic evaluation section.

12. General and administrative overhead. These items are highly variable from company to company, and the allowance needed for them depends on the operator's specific setup. Administrative overhead can be determined only from the company's own records. The significance of general overhead costs can be recognized from the list in Table 4 of some of the items for which an allowance for cost of operation must be included. For estimating purposes, general and administrative overhead can conveniently be taken as a percentage of direct labor and supplies (Items 1-3, 5, 6 in the operating cost build-up). A figure of 50% is arbitrarily used in the examples.

13. Royalties. New processes offered to the refining industry are normally subject to a royalty or process licensing fee which offsets the cost of research and development by the organization offering the process. The way in which these fees are charged varies, but they can usually be expressed in terms of the amount of feed run. For the processes under consideration, therefore, these costs are illustrated at a rate of 5¢/bbl. of feed for coking, and 2¢ for hydrofining. They are charged on the basis of a 90% service factor, but are included in indirect costs.

14. Insurance and local taxes. Taxes vary widely with location. Losses by fire and other hazards can be kept low, with care. For these examples, 1% per year on the total plant investment is used to cover these items.

Table 5. Economics calculations.

Investments	9000 B/CD[g] Fluid Coking	10,800 B/CD[g] Hydrofining
Process Unit	$2,300,000	$1,000,000
Off-sites	1,400,000	750,000
Interest during constr'n.	225,000	105,000
Start-up costs	100,000	65,000
Working capital	275,000	310,000
Total	$4,300,000	$2,230,000
Cost Analyses; Yearly Basis[a]		
I. Original investment basis		
1) Operating cost, ex-depr'n.	$ 700,000	$ 465,000
2) Depr'n. straight line, 15 yr.[b]	270,000	130,000
3) Total oper. cost, incl. depr'n.	970,000	595,000
4) Operating margin[c] (per bbl.)	3,280,000($1.00)	1,295,000(32.8¢)
5) Gross profit	2,310,000	700,000
6) Income tax (52%)	1,200,000	365,000
7) Net profit	1,110,000	335,000
8) Return on orig. investment	25.8%	15.0%
II. Sinking Fund Depreciation Basis		
1) Operating cost, ex-depr'n.	$ 700,000	$ 465,000
2) Depr'n., 4% sinking fund, 15 yr.[d]	200,000	95,000
3) Total oper. cost, incl. depr'n.	900,000	560,000
4) Operating margin (per bbl.)	3,280,000($1.00)	1,260,000(32.0¢)
5) Gross profit	2,380,000	700,000
6) Income tax[e]	1,200,000	365,000
7) Net profit	1,180,000	335,000
8) Return on outstanding invest.	27.4%	15.0%
III. Constant Return on Net Investment Basis		
1) Operating cost, ex-depr'n.	$ 700,000	$ 465,000
2) Operating margin (per bbl.)	3,280,000($1.00)	1,105,000(28.0¢)
3) Cash available	2,580,000	640,000
4) Income tax[e]	1,200,000	265,000
5) Net cash available[f]	1,380,000	375,000
6) Return on net investment[h]	31.6%	15.0%

[a] *In fluid coking the operating margin is fixed and the returns calculated; in hydrofining, the return is assumed and the required margins calculated.*

[b] *On total investment excluding working capital.*

[c] *Total products value less feed cost.*

[d] *Annual amount needed to retire total investment ex-working capital when compounded annually at 4% net after taxes on the sinking fund.*

[e] *Income tax calculated after straight-line 15-yr. depreciation in all cases.*

[f] *For return plus retirement of total investment ex-working capital.*

[g] *Barrels per calendar day.*

[h] *The fact that these figures are close to the ratios of Items III (5) to the total original investments is fortuitious. The returns indicated are on net investment after allowing for the year-by-year decrease in investment resulting from application of depreciation allowances, and for the subtraction of these allowances from the net cash available each year.*

Economic evaluation (Investment analysis)

While these operating costs can be used for comparative evaluation of directly competing processes, the usual aim of an economic evaluation is to determine the return on investment which can be earned by the proposed plant for a given feed/products margin. Alternatively, the margin necessary to earn a given return on the investment, i.e., the cost of the operation including return, may be desired.

In Table 5, economics calculations are carried out on the two examples used. First, the over-all investment requirements are developed. Investments for the process unit and off-sites are taken directly from Table 3. Some recognition of interest charges during construction should be given. In Table 5, this is assumed at the rate of 6% for half the total construction period. A total construction period of two years was assumed for both plants.

Start-up costs represent another investment item. These are the costs of operation of the unit during the period when no products, or less than the normal amount of products, are being produced. It allows for operator training and low service factor during the first year. An amount equal to 50 days of total operating costs, excluding return, is used in the examples.

Working capital must be considered. This allows for all items for which money must be made available but which will, on the average, be returned at the end of the plant's life.

It includes catalyst and chemicals inventory, feed and products inventory, and an allowance for the time after operating costs are incurred, but before payment for products has been received.

For the coking case, no catalyst is used and no treating chemicals are involved. The feed and products inventory is taken at about 12 days of product value and the allowance for billing time at 30 days of operating costs, plus depreciation. Since hydrofining requires catalyst, the working capital calculation for this example is more complete. For catalyst investment, it was assumed that the catalyst cost in Table 3 was obtained with $1/lb. catalyst at 10 wt. feed/wt. catalyst/hr. Hydrofining space velocities vary widely, and this figure must be taken purely as illustrative. To handle 12,000 bbl./stream day of 300 lb. per bbl. feed at 10 wt. feed/wt. catalyst/hr., 15,000 lbs. of catalyst is required for the reactor. A full extra charge is sometimes kept on hand for emergencies, but, because of the long life and easy availability of hydrofining catalyst, this is not included in the example. On the other hand, the catalyst in the unit is charged off as an operating cost over its life, and the effective average investment in catalyst is less than its initial cost. Accordingly, the catalyst inventory charge is taken at two-thirds the cost of a reactor load, or, at $1/lb., $10,000.

For the hydrofining case, only a few days' storage capacity is required, provided that good scheduling on turnarounds and maintenance is obtained. Accordingly, six days of product inventory is included in working capital. At a value of 9¢/gal., this is $250,000. Allowance for billing time at 30 days' operating costs including depreciation, is $50,000. The total working capital then becomes $310,000 for the hydrofining illustration.

Provision of housing may be necessary, especially for grass roots plants at new locations. If the proposed operation is large compared to the size of the community in which it will be carried out, it may be necessary to include housing and community facilities investment as a part of the over-all plant investment upon which a return must be earned. For individual process operations in a refinery, however, this situation does not arise and is not taken into account in this development.

It is often convenient to evaluate the economic outlook in terms of the process investment, or process investment plus new off-sites, only. When this basis is used, the omission of some capital items must be recognized, and a higher level of return required for justification of the project.

Table 6. Stripped-down cost estimates[a].

		10,000 B/SD[b] Fluid Coking	12,000 B/SD[b] Hydrofining
On-site Investment		$2,300,000	$1,000,000
Operating Costs, per day			
1) Operating labor	(No. @ $3/hr.)	(3) $216	(1) $ 72
2) Supervision & Other labor	(15% of 1)	32	12
3) Maintenance labor	(4% on inv.)	252	110
4) Payroll overhead	(20% on 1-3)	100	39
5) Operating supplies		20	12
6) Maintenance labor	(2% on inv.)	125	55
7) Purchased utilities		25	135
8) Water		50	50
9) Fuel		—	265
10) Catalyst		—	10
11) Total direct[c]		$800(8.9¢)	$760(7.1¢)
12) Local taxes, ins.	(1% on inv.)	65	27
13) Depreciation	(6.7% on inv.)	420	183
		$1285	$970
14) Operating margin[d]		9000	3550
15) Differential		7715	2580
16) Annual percent on invest.		124%	94%

[a] *Showing effect of omitting investments and operating costs associated with off-site facilities.*
[b] *Barrels per stream day.*
[c] *Figures in parentheses are per barrel, at 90% service factor.*
[d] *From Table 5, Basis I.*

Economic evaluation (Cost analysis)

There are a number of ways in which cost analyses can be set up. For purposes of illustration, we will discuss three. The first uses the original investment basis and conventional straight-line depreciation; the second uses original investment basis and sinking fund depreciation; the third figures the net investment at any time during the life of the plant and takes a constant return on that investment, adjusting write-off so as to keep the over-all cost of the operation constant.

For all of these methods, the operating cost ex-depreciation is constant. It is convenient to work on a yearly basis and this basis is used in Table 5. Depreciation is handled differently for each analysis, but all depreciate the total investment, excluding working capital, completely. A 15-yr. depreciation period is used. This is reasonably representative of allowable depreciation rates, averaged for income tax purposes. Actually, allowable rates vary with the unit and with parts of a unit, and any detailed analysis should take these into account. On the other hand, the effective depreciation rate is also affected by obsolescence and market changes, and this must be taken into account when the write-off period for making true cost calculations is estimated. Income tax is taken at 52% of gross profit after straight-line depreciation in all cases.

Coking example

Method I. The cost analysis relating return after straight-line depreciation to the original investment, is most generally used in the petroleum industry. It does not take into account the fact that after the first year's operation the investment upon which return must be earned has been decreased. However, this provides a factor of safety and those using this method make the necessary adjustment intuitively. For the fluid coking example in Table 5, a margin of $1.00/bbl. of products value over feed cost is used for illustration. It is a reasonable margin, however, and can be obtained from the yield structure of Table 1, using conservative values for feed and products.

Method II. Use of sinking fund depreciation changes only the figure for the amount of money which must be set aside to amortize the plant over the 15-yr. period. Because income tax is based on profit, using standard depreciation, the income tax charge against the operation does not change. In Table 5, the reduction in operating costs by using sinking fund depreciation increases the net return somewhat, but not to a large extent. For

the coking case the return rises from 25.8 to 27.4%.

Method III. This determines the constant return on net investment for a constant operating margin over the life of the plant and is of considerable interest. Because the average investment in the plant on a straight-line depreciation basis would be just about one-half the original, it might appear that the return on average net investment would be roughly twice that on total original investment. This is not the case, however, because the return required early in the life of the plant when the net investment is high is more important than the smaller return required later. Use of this method does show some increase in return, however, to 32.0% for the fluid coking operation. Calculations in this case are done by assuming a probable percent return, determining the money left for amortization of the original investment after subtracting this return (and the income tax, calculated on straight-line depreciation basis) from the operating margin available, calculating the return on the depreciated, "net" investment for the next year, and continuing this for the life of the plant. Alternatively, tables of compounding factors can be used. In either case the assumed percentage return must be adjusted by extrapolation until the investment is written off to the working capital level.

Hydrofining example

The hydrofining example is set up in Table 5 to show the margin required to give a 15% return on all bases. In this example the original investment basis requires a margin of 33¢/bbl. to give 15% return. The sinking fund depreciation basis requires 32¢/bbl. The constant return on net investment basis requires 28¢/bbl.

It is of interest to note the small difference in results. This, in effect, justifies the use of the first-year return on original investment technique. However, with other situations the effect of the different bases could be greater.

No consideration is given the capital structure of the company operating the plant. In the petroleum industry the ratio of bond to equity capital is usually low, but when borrowed capital is used, economics are affected in two ways. First, interest rate on bonds is lower than the expected return on equity investment. This could lower the over-all return, although an increase in bonded indebtedness increases the risk, and the return required on the equity investment. In addition, interest on bonds is a cost of operation and this part of the return on total investment does not have income tax charged against it. Whether the effect of bonds in the over-all financial structure must be taken into account depends on the position of the organization for which the process is being studied.

Short cuts

The previous calculations have been made on the basis of daily plant costs for operation and annual figures for the economics. It is sometimes convenient to work on the bbl./day basis. The techniques used are essentially the same as in the foregoing sections, but the effect of plant size on investment is more clearly brought out. For planning studies projected some time into the future, the bbl./day basis can often be simplest and most revealing.

The discussion on build-up of daily operating costs shows that many items are related either to investment or to operating labor requirements. Using the proportions employed in the detailed build-up, the daily operating cost can be written as follows:

Daily cost (\$) =

$$I\ (30\,P + 48\,M + 27.5)$$

where I is the process unit plus total off-sites investment in millions of dollars, M is the maintenance rate, direct labor plus materials, in percent on total investment, and P is the pay rate for operators in \$/hr. This figure does not allow for catalyst and chemicals, utilities, fuel, royalties, or depreciation.

If the maintenance rate is taken as 6% and the operating labor rate at \$3/hr., the above equation reduces to daily costs equivalent to 14.8%/yr. on the total plant investment including off-sites. To allow for catalyst, utilities, fuel costs, and royalty, the 14.8%/hr. will rise to the order of 20-30%/yr. The reason for this wide range is obvious, but for very rough projection purposes 25% is reasonable. To get total costs, including depreciation, the figure should be 30-35%/yr. Caution must be employed in using these techniques, since many rough allowances are involved.

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Stripped estimates

It is of interest to compare the operating costs arrived at using the techniques described above with the stripped-type estimates which are often employed. Stripped estimates are useful and need not be misleading. However, the difference between the two types can be significant, with allowance for investment off-sites and for operating overheads and depreciation omitted from the stripped estimate.

Some examples of the way this works out are shown in Table 6. On a stripped basis the direct expenses for coking are 9¢/bbl., and for hydrofining are 7¢/bbl. After allowing for local taxes and depreciation on the on-site investment (but not royalty), the returns on this investment (before income tax) are 124% and 94%, respectively. These figures make use of the same basic operating costs and margins as Case I of Table 5.

Summary

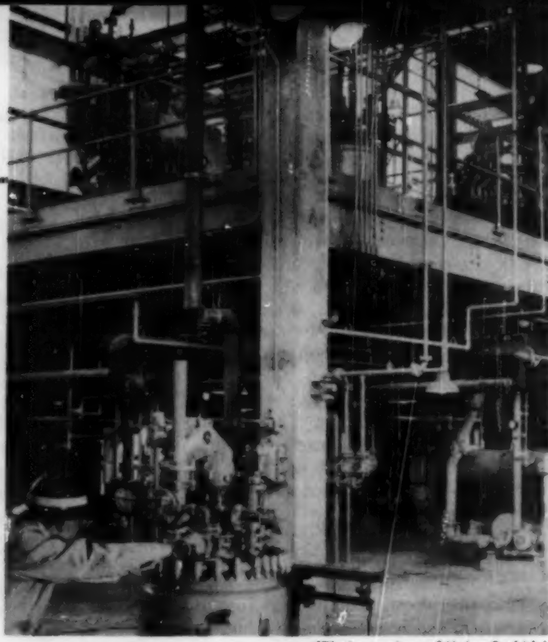
Techniques for estimating the operating costs of projected petroleum processes have been surveyed. The survey reviews what cost items should be considered, and how each should be handled. Although all items may not be included in the cost build-up, all should be taken into account if unrecognized omissions are to be avoided. Proper consideration of all investment items, and of all operating overheads should be given.

Methods of analyzing the economic position of the projected operation are also reviewed. The need for using bases understood and accepted by those for whom the estimate is made is emphasized. The use of new and improved techniques for economic evaluation should be accompanied by a clear statement of the differences in the new method.

Short cuts are often useful, especially for economics of projected processes and for investigation of operations contemplated sometime in the future.

LITERATURE CITED

1. Barr, F. T., and C. E. Jahnig, *Chem. Eng. Prog. 51*, 167 (1955).
2. Saxton, A. L., H. N. Weinberg, and R. O. Wright, preprint for 25th Midyear Meeting of A.P.I. Division of Refining, Detroit (May 12, 1960).
3. Morbeck, R. C., *Oil and Gas.*, J., Vol. *53*, No. 35, p. 94 (Jan. 3, 1955).
4. Van Noy, C. W., T. C. Dunville, R. G. Dressler, and C. C. Chaffee, R. I. 4524, U. S. Bu. Mines (Nov. 1949).
5. Hirsch, J. H. and E. M. Glazier, *Chem. Eng. Prog., 56*, 37 (Dec. 1960).
6. Dickens, S. P. and F. R. Douglas, *Chem. Eng. Prog., 56*, 44 (Dec. 1960).



(Photo courtesy of Union Carbide)

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Equipment costs

Select most promising processes and products by use of these cost estimation and analysis charts.

Chemical engineering cost estimation and analysis are of great importance in today's research operations because research and development have become big business, involving expenditures of almost ten billion dollars annually in the United States. It has become increasingly important in this highly competitive business to select early during the research cycle those processes and products possessing most promise for commercialization.

Cost estimation and analysis at the Southern Utilization Research and Development Division is performed during every phase of research as a part of an intensified research program. Cost research identifies items of greatest cost, and is useful in considering the feasibility of proposed research, in furthering process and product development, in advancing the commercialization of the more profitable processes, and in evaluating the impact of research on industry.

Methods have been sought to expedite this activity since evaluations must be made on many processes and products by relatively few personnel. Equipment costs, obtained largely from equipment manufacturers during process evaluations over the past six years, have been classified by material of construction and size, plotted, and are presented for quick reference and use. These costs have been adjusted to the December 1959 level using the appropriate Marshall and Stevens equipment cost indices.

The equipment costs presented are for units that have found extensive application throughout the over-all chemical processing industry although developed for cotton chemical processing. The agitators of Figure 1 are equipped with Class I Group D explosion-proof motors, as are the horizontal dryers of Figure 2.

The kettles priced in Figure 11 are those recommended by manufacturers for use in varnish manufacturing. The smaller ones are priced with and without a truck, the larger kettles are stationary. Refractory for a typical varnish cooking compartment with a pit costs approximately $1450, burners cost $450, and an exhaust system costs $850.

The refrigeration systems of Figure 4 exclude cooling towers which cost $300 for a 7.5-ton system and $5000 for a 130-ton system. The vertical storage tanks of Figure 12 are for a product having a specific gravity of one or less. For the steel tanks, shop and materials account for 60% and field erection 40% of purchased cost.

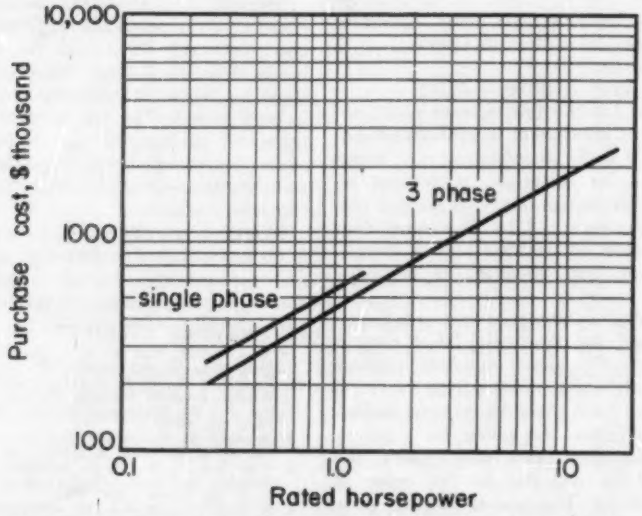


Figure 1. Purchase costs of 304 stainless gear-driven agitators vs. horsepower. (Basis: M.&S. process equipment index = 236.1)

ACKNOWLEDGMENT

The authors wish to thank G. I. Pittman for preparation of the charts used in this article.

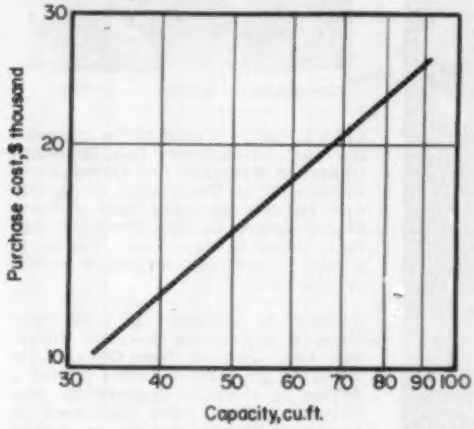


Figure 2. Continuous horizontal dryer costs. (Basis: M.&S. process equipment index=236.1)

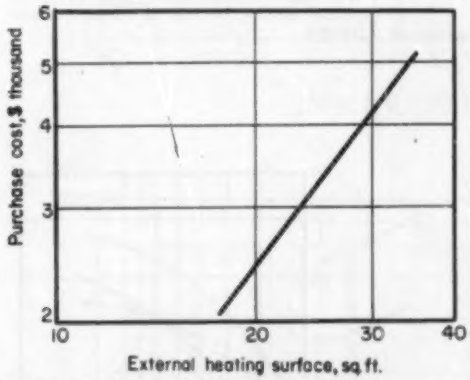


Figure 3. Costs of long-tube, rising film evaporators with stainless tubes and separator. (Basis: M.&S. process equipment index=236.1)

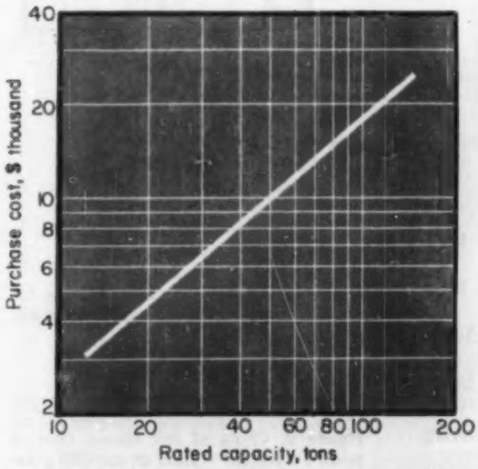
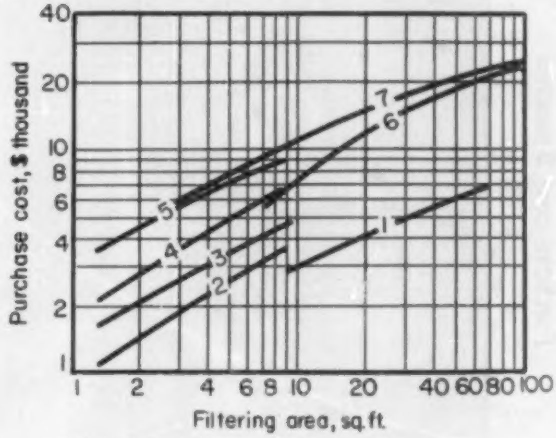


Figure 4. Costs of refrigeration units. (Basis: M.&S. process equipment index=236.1)



Curve	Description
1	Vertical type, pressure leaf, 316 SS
2	Horizontal plate, filter only, mild steel
3	Horizontal plate, filter unit, mild steel
4	Horizontal plate, filter only, 304 SS
5	Horizontal plate, filter unit, 304 SS
6	Continuous vacuum drum, filter only, SS
7	Continuous vacuum drum, filter unit, SS

Figure 5. Purchase costs of filters for various filtering areas. (Basis: M.&S. process equipment index=236.1)

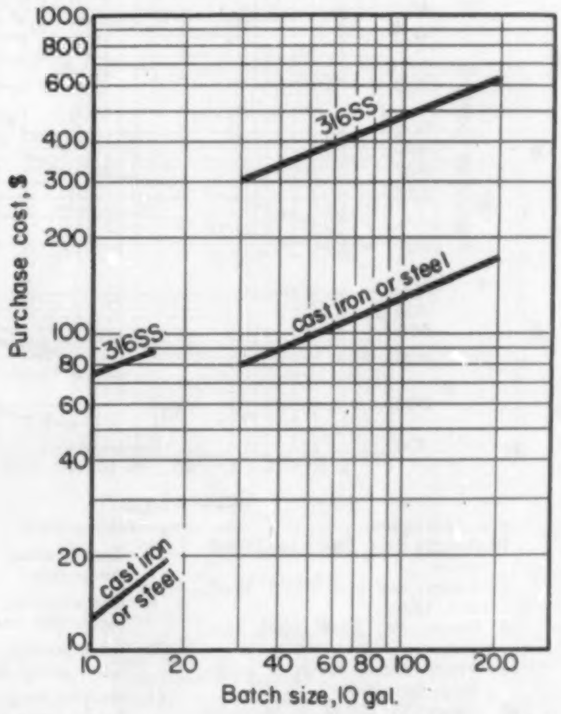


Figure 6. Purchase costs of cartridge type filters vs. batch size. (Basis: M.&S. process equipment index=236.1)

Turn page for figures 7 through 12

Equipment costs *continued*

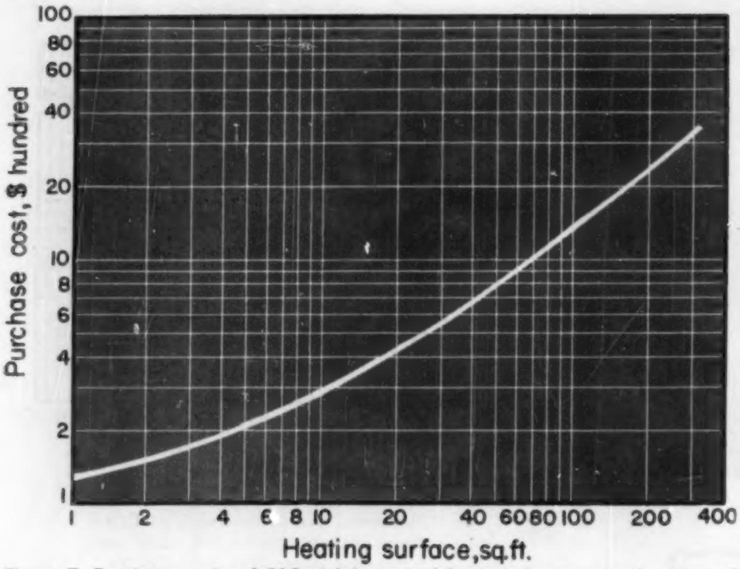


Figure 7. Purchase costs of 316 stainless steel heat exchangers as function of heating surface. (Basis: M.&S. process equipment index=236.1)

Decossas Koltun Patton

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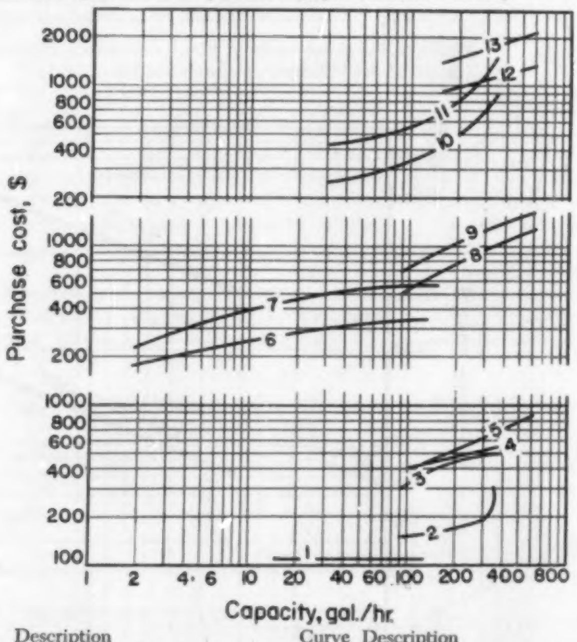
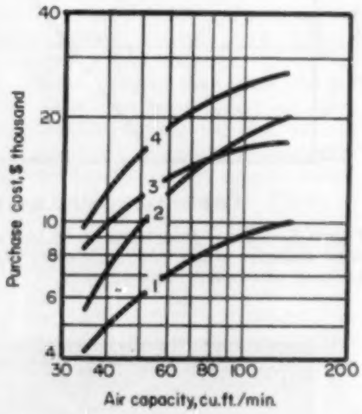


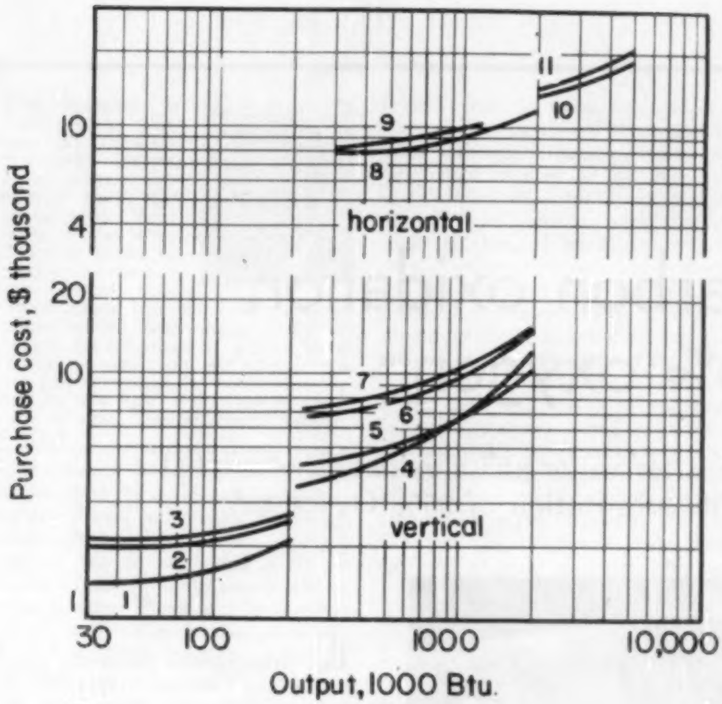
Curve	Description
1	Rotary; steel; 25-ft. head; incl. motor
2	Rotary; cast iron; 200-ft. head; incl. motor
3	Rotary; SS; 25-ft. head; incl. motor
4	Rotary; SS; 60 lb./sq. in. gauge head; incl. motor
5	Rotary; SS; 150 lb./sq. in. gauge head; incl. motor
6	Reciprocating; cast iron; 25-ft. head; pump only
7	Reciprocating; cast iron; 25-ft. head; pump and motor
8	Reciprocating; SS; 25-ft. head; pump only
9	Reciprocating; SS; 25-ft. head; pump and motor
10	Reciprocating; cast iron; 200-ft. head; pump only
11	Reciprocating; cast iron; 200-ft. head; pump and motor
12	Reciprocating; SS; 150 lb./sq. in. gauge; pump only
13	Reciprocating; SS; 150 lb./sq. in. gauge; pump and motor



Curve	Description
1	Pump only, steel
2	Pump only, bronze
3	Pump, motor and coupling, steel
4	Pump, motor and coupling, bronze

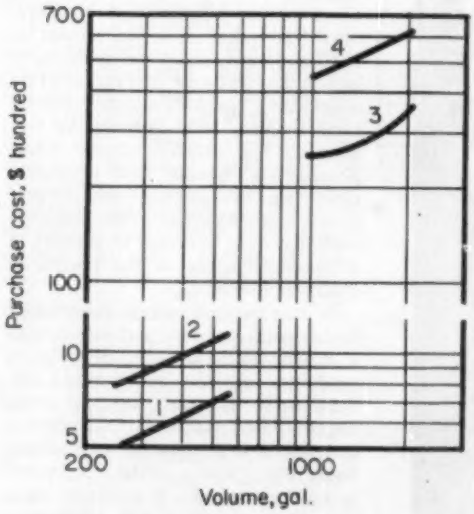
Figure 8. Purchase costs of pumps for obtaining 26-in. vacuum. (Basis. M.&S. process equipment index=236.1)

Figure 9. Chart at left shows cost of pumps used for liquids of specific gravity of 0.8 to 1.3. (Basis: M.&S. process equipment index=236.1)



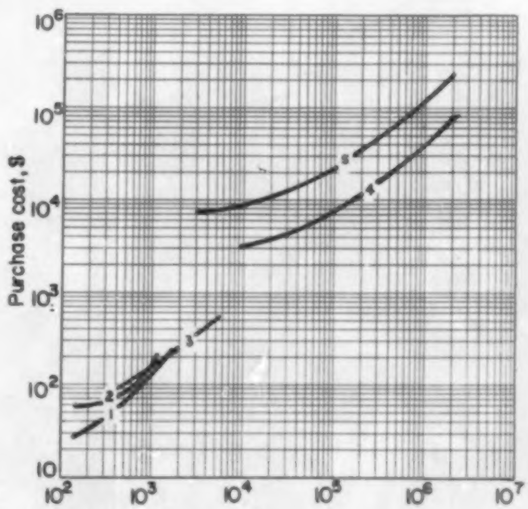
Curve Type of Heating
1 Pilotstat
2 Oil-fired
3 Combination gas–light oil
4 Atmospheric Pilotstat
5 Light oil fired–standby gas pilot
6 Heavy oil–fired
7 Combination gas–heavy oil
8 Standby gas pilot–light oil fired
9 Standby pilot–combination gas-oil
10 Light oil fired
11 Heavy oil fired

Figure 10. Purchase costs of Dowtherm vaporizers. (Basis: M.&S. process equipment index=236.1)



Curve Description
1 Portable kettle without truck
2 Portable kettle with truck
3 Fixed kettle, gas fired with accessories
4 Fixed kettle, dowtherm heated with accessories

Figure 11. Costs of 304 stainless kettles. (Basis: M.&S. process equipment index=236.1)



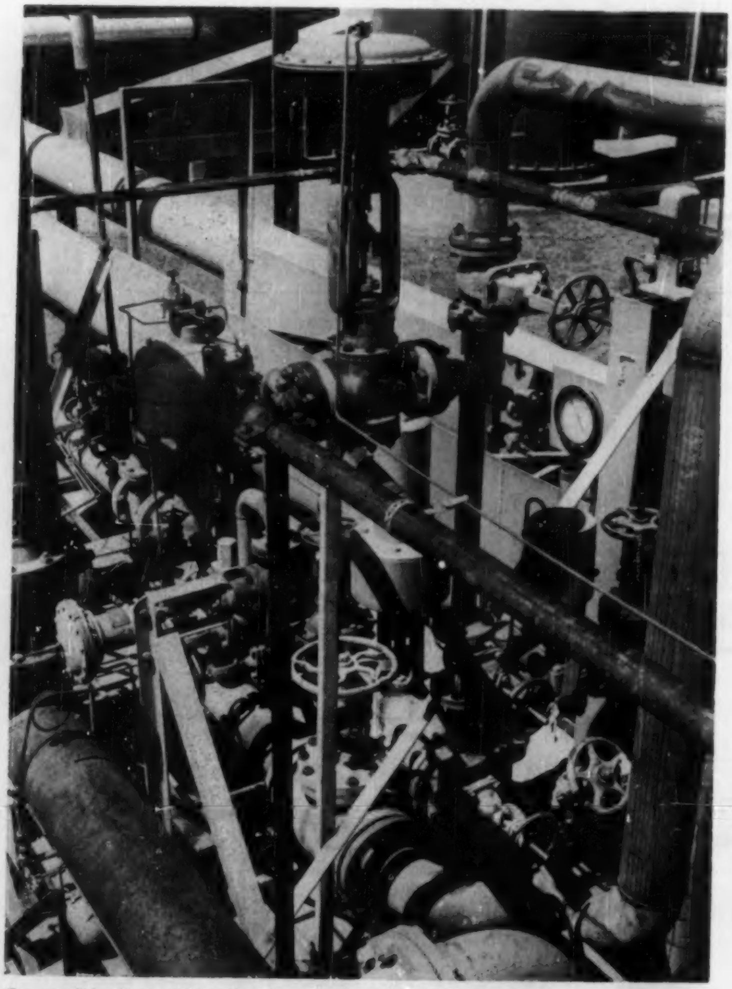
Curve Description
1 Horizontal, above ground, steel
2 Skid tank, steel
3 Horizontal, underground, steel
4 Vertical, above ground, steel, for liquids of specific gravity 1 or less
5 Vertical, above ground, stainless, for liquids of specific gravity 1 or less

Figure 12. Chart above shows costs of storage tanks. (Basis: M.&S. process equipment index=236.1)

James M. Robertson
Celanese Chemical Company

Hydrocarbon oxidation with 95% oxygen

New commercial process for vapor phase oxidation of aliphatic hydrocarbons highlights substitution of 95% O_2 for air.



Oxygen injection station showing complexity of piping and close-coupling valves for safe mixing of the oxygen and hydrocarbon stream.

The hydrocarbon oxidation process used by Celanese Corporation of America at Bishop, Texas, may be classed as a vapor phase, non-catalytic operation conducted under conditions of moderate pressure and temperature. The plant came on stream in 1945 and represented one of the early large-scale attempts to manufacture oxygenated petrochemicals directly from aliphatic hydrocarbons. Air was used as the oxidizing agent while propane and butane, feed separately rather than as a mixture, were the preferred raw materials. Four separate oxidation units operated in parallel. A schematic diagram of the process is shown in Figure 1a.

In this process, air is compressed to moderate pressure and mixed with a stream containing N_2, degradation products, and the hydrocarbon material to be oxidized. Reactant ratios are controlled so that the O_2 content is maintained below the lower explosive limit. The gaseous mixture is heated in a furnace, similar to a refinery pipestill heater, where the exothermic combination of O_2 and hydrocarbon occurs. The hot reaction product stream passes through a heat exchanger where most of its heat is recovered as steam to be used elsewhere in the plant. Organic chemical products are scrubbed from the cool reaction gas in absorbers. Crude products are removed as water solutions while nitrogen, degradation products, and unreacted hydrocarbons are recycled back to the reaction feed.

Removal of excess inert nitrogen is

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accomplished by withdrawing a side stream from the hydrocarbon-nitrogen recycle stream and passing it through a conventional hydrocarbon recovery system. The recovery unit is similar to the oil absorption systems found in most gasoline plants and gas cycling plants, except that an absorption efficiency of 99.5% must be achieved. Nitrogen and degradation products are vented from this section to the atmosphere while recovered hydrocarbon is returned to the reaction. Fresh feed is added at this point.

This reaction yields a mixture of low molecular weight aliphatic oxygenated chemicals. These products include the aldehydes, alcohols, oxides, ketones, and acetals. The separation of an aqueous mixture such as this into individual components of adequate purity is a somewhat complex task; thus considerably more of the plant proper is devoted to the purification and further reaction of products than to their initial formation.

Oxidation plant expansion

In 1957 it became necessary to increase the basic capacity of the hydrocarbon oxidation units. Substitution of 95% O_2 for air as the oxidizing agent was chosen as the method of expansion for several reasons:

1. Capacity of the existing equipment could be increased, providing increased production without the expense of building parallel units. This capacity increase was achieved by replacing inert N_2 in the system with reactive hydrocarbon and O_2.

2. Elimination of the N_2 makes it possible to attain more favorable reaction conditions which increase the conversion efficiency of hydrocarbon raw materials to valuable products.

3. Physical characteristics of some major equipment in the existing plant placed a restriction upon the type feedstock which could be processed. It was possible to oxidize propane with air in only two of the oxidation units, although either propane or butane could be used in the other two units. Substitution of O_2 for air removed these limitations primarily because of changed loading conditions on the hydrocarbon recovery systems.

The attainment of more favorable reaction conditions was an extremely important factor in this choice, and a more detailed explanation of the point is in order. In an oxidation reaction of this type the ratio of hydrocarbon to O_2 exerts a very strong effect upon product yields. In general, a greater hydrocarbon ratio increases the yields of aldehydes, alcohols, and ketones but decreases the formation of CO_2, CO, and CH_4. Figure 2 shows how the product yield increases with hydrocarbon to O_2 ratio in the vapor phase oxidation of propane. The substitution of 95% O_2 for air in the reaction eliminates the bulk of the N_2 from the system and makes possible the attainment of higher hydrocarbon concentrations in equipment of reasonable size.

In addition to the increase in product yield per gallon of raw material consumed, the reduced formation of carbon oxides offers a significant secondary advantage. A smaller volume of degradation products is passed through the oil absorption hydrocarbon recovery equipment, thus a smaller volume of propane is lost out the top of this absorber.

To accomplish the desired expansion, a new unit to produce 350 tons/day of 95% O_2 was installed and two

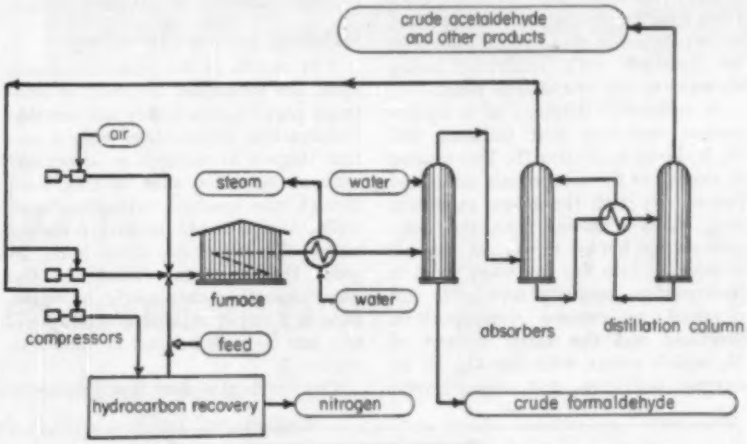


Figure 1a. Schematic diagram of the hydrocarbon oxidation unit based on air.

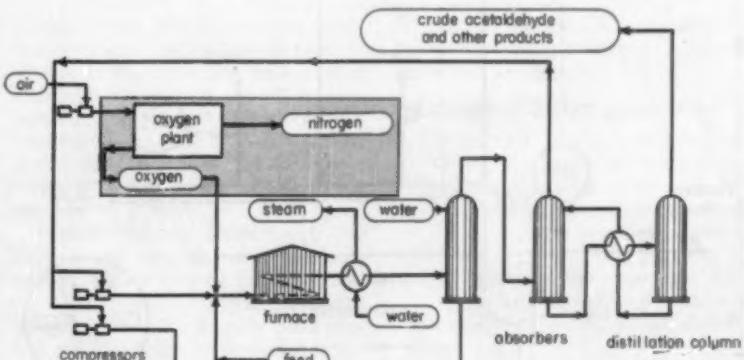


Figure 1b. Gray area shows modification for using 95% O_2 in oxidation unit.

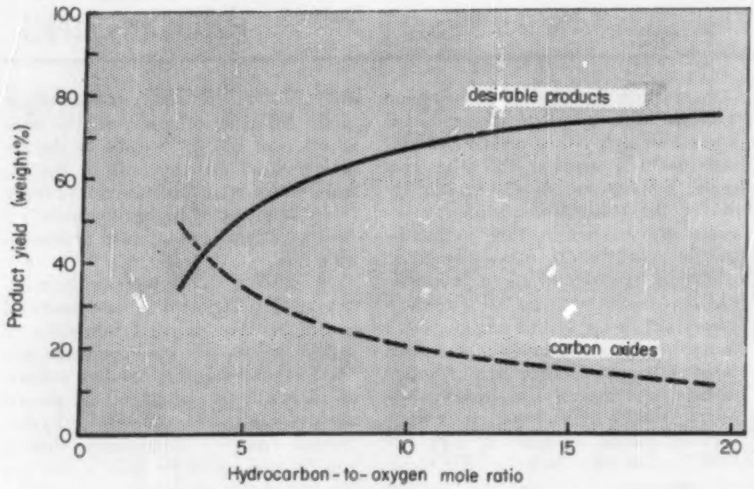


Figure 2. Effect of reactant ratio on product yield in oxidation of propane.

of the four air oxidation units were modified to permit use of this relatively pure O_2. Only two oxidation units were modified to use O_2 feed, because an expansion of this magnitude could be handled with relatively minor changes in the rest of the plant.

A schematic diagram of a hydrocarbon oxidation unit utilizing 95% O_2 is shown in Figure 1b. The process is similar to the air process described previously, with the major exception that N_2 is removed from the compressed air before the O_2 of this air is injected into the oxidation zone. A hydrocarbon recovery section is still required to remove decomposition products and the small amount of N_2 which enters with the O_2. In an oxygen oxidation unit, the "inerts" vented from the hydrocarbon recovery system are combustible and may be utilized elsewhere in the plant as fuel.

Handling pure oxygen safely

The success of this process depends upon the controlled addition of relatively pure O_2 to a highly inflammable hydrocarbon stream. Obviously a certain degree of danger is associated with an operation such as this, even though the reactant ratios are controlled so that the O_2 content is always below the lower explosive limit. In order that maximum safety in the plant operating area might be maintained, a rather elaborate mixing system has been developed as shown in Figure 3.

Oxygen, whose flow is regulated by a flow recording control instrument, enters a sparger through a fast-acting safety shut-off valve. The sparger is shaped like a spider held perpendicular to the flowing hydrocarbon stream in the reactor feed line, and has holes drilled in its arms on the upstream side only. The sparger hole area is sized so that a specified pressure differential exists between the O_2 inside the sparger and the hydrocarbon in the main line. This pressure differential is sensed constantly by an instrument which actuates the safety shutdown system if the sparger pressure approaches that of the hydrocarbon line.

If the pressure differential drops to a pre-set level, the snap-acting controller releases the control air pressure on a system of rapid-response pneumatic valves. This causes the two O_2 valves to close; simultaneously, the two steam valves and the two vent valves open. Steam purges the O_2 from the system, and the central zone in the O_2 line whose pressure has been reduced to atmospheric provides a positive barrier which prevents hydrocarbons in the reaction line from leaking back through the sparger into the line containing pure O_2. The O_2 vent relieves pressure on the O_2 feed line.

The introductory photograph shows one of the O_2 injection stations and the complexity of the piping and the close-coupling of valves necessary to achieve the safe mixing of O_2 and hydrocarbons.

This hydrocarbon oxidation process, like any continuous chemical reaction, is highly sensitive to fluctuations in pressure, temperature, or reactant purity. The large volume of the system makes an oxidation unit somewhat slow to recover from upsets, and during the time required to re-establish optimum conditions a product loss accompanied by carbon deposition within the equipment usually occurs. For this reason, it is necessary to provide a constant, dependable source of O_2 to be used in the process described.

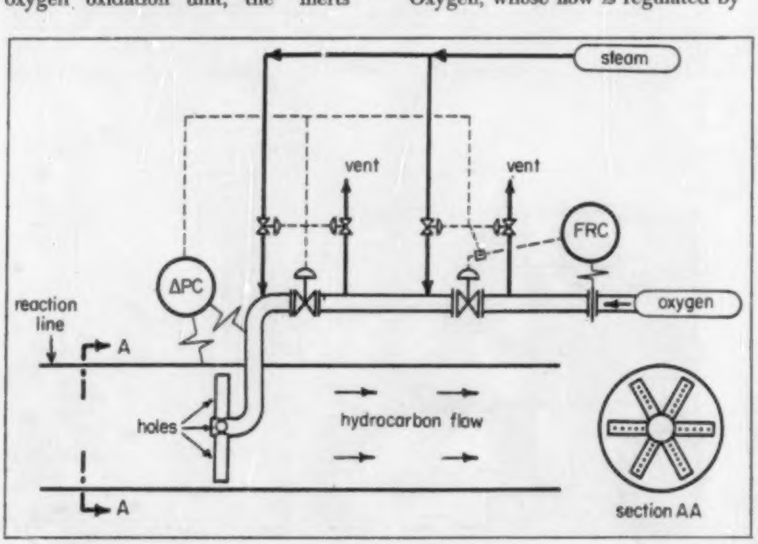


Figure 3. Oxygen injection system used to maintain maximum plant safety.

CONCLUSION

The direct addition of O_2 to an aliphatic hydrocarbon molecule by non-catalytic means has been attempted by many others. However, the process discussed here is the only one which has reached the stage of successful commercial development. The purpose of this article was to show that under the proper conditions vapor phase non-catalytic oxidation of hydrocarbons with 95% O_2 can be practical on a commercial scale. #

J. B. Bingeman
Rexall Chemical Co.
L. B. Reynolds
Ethyl Corp.

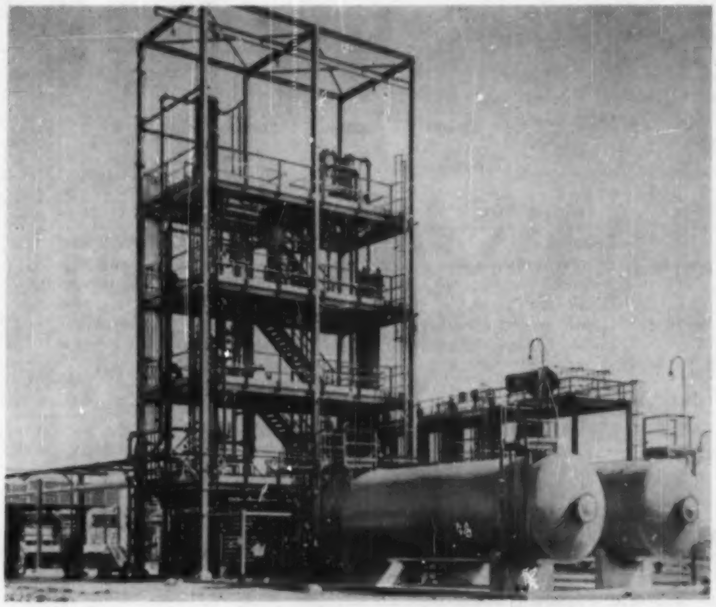


Figure 1. Over-all view of HCl recovery unit.

Design and operation of HCl recovery unit

Proof of the pudding: actual plant operation of a cascaded falling-film absorber and packed-column stripper tests design reliability.

To recover HCl from a stream of inert gases varying in rate and HCl content, an aqueous absorption-stripping system was installed in 1954 at the Houston plant of Ethyl Corporation. This installation differed from the usual HCl absorption in that a gaseous HCl product was desired for recycle to process. Consequently, HCl is stripped out of the strong hydrochloric acid absorption product and the resultant weak acid is used as the absorption medium instead of water.

An over-all view of the absorber and stripper is shown in Figure 1 and closeups of the principal equipment in Figures 2 and 3. At design conditions, feed gas enters the plant at 44 to 65 volume-percent HCl, the remainder being ethylene, ethane, methane, hydrogen, and carbon dioxide. As shown in Figure 4, the HCl content fluctuates between 44 and 65 volume-percent and the rate varies over a relative range of 1.5 to 3.5. It will be noted that the minimum HCl concentration occurs at the maximum gas rate and vice versa.

Because the feed fluctuates in HCl content and rate, the absorber must operate with a varying HCl feed and therefore with a varying quantity being absorbed. To simplify plant control, weak acid is fed to the absorber at a constant rate. As a result, the concentration of strong acid product cycles from 32 to 33% HCl. The cooling water temperature and the HCl in the off-gas also vary slightly but these variations have a negligible effect and are ignored.

Establishing design parameters

A. Bases for design calculations. After calculations for preliminary screening, bases were set for definitive design. They are listed below for use in sample calculations.

1. Absorb in three sections: Adiabatic tails tower and two cascaded cooled falling-film absorbers
2. Strong acid to be 32 wt.-% HCl
3. Design load: 2300 lb. HCl/hr. (54 mol-% HCl in feed gas)

Table 1. Equipment summary

No.	Description	Type	Packing: Material	Packing: Type	Packing: Size, in.	Packing: No. sections	Packing: Total depth, ft.	Tower material	Design duty, lb. HCl/hr.
C-1	Tails tower	packed	porcelain	raschig rings	2	1	8	Haveg 41	Absorb 569 lb. HC1/hr. from 22 mole-% feed
C-2	Stripper	packed	porcelain	raschig rings	2	2	20	Impervite	1,771

No.	Description	Type	Tubes: Material	Tubes: No.	Tubes: Length, ft.	Tubes: I.D., in.	Heat load Btu/hr.
E-1	Reboiler	S&T	Impervite	206	9	[illegible]	3,912,000
E-2	Primary condenser	S&T	Impervite	110	9	[illegible]	
E-3	Secondary condenser	S&T	Impervite	110	9	[illegible]	1,102,000
E-4	Weak acid cooler	Drip	Impervite	60	9	4	1,640,000
E-5	Lower cooled absorber	S&T falling film	Impervite	110	9	[illegible]	
E-6	Upper cooled absorber	S&T falling film	Impervite	110	9	[illegible]	1,191,000

No.	Service	Type	Flow, gal./min.	Head, ft. liquid	Material
P-1, 2	Weak acid pumps	centrifugal	34	83	Karbate
P-3, 4	Strong acid pumps	centrifugal	36	85	Karbate

No.	Service	Diam., ft.	Length ft.	Nominal volume, gal.	Construction material
V-1	Weak acid holdup	10	30	20,000	rubber-lined steel
V-2	Strong acid holdup	10	30	20,000	rubber-lined steel
V-4	Product KO drum	1.5	4.5	65	rubber-lined steel

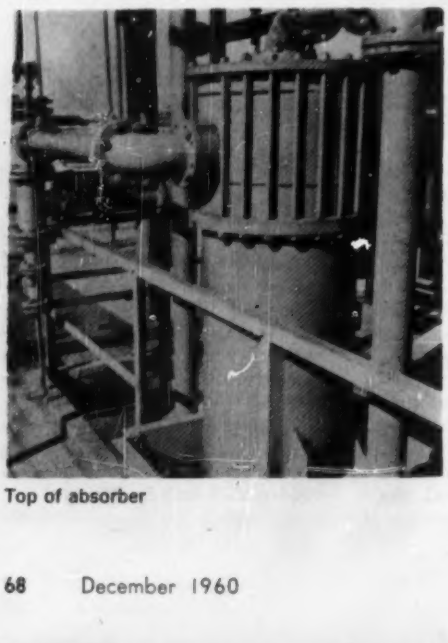
4. 99% recovery of HCl
5. Weak acid feed to tails tower to be 20 wt.-% HCl
6. Two 85-tube cooled sections
7. Liquid temperature changes linearly down cooled sections
8. Mass transfer coefficient, Kg= 15 lb./(hr.)(sq. ft.)(atm.) (an average of Ethyl experience at gas rates in the same flow region)
9. Absorption breakdown:
a. 25% in tails tower
b. 37.5% in upper cooled absorber
c. 37.5% in lower cooled absorber

B. An over-all material balance is prepared based on the feed composition and the desired strong and weak acid concentration.

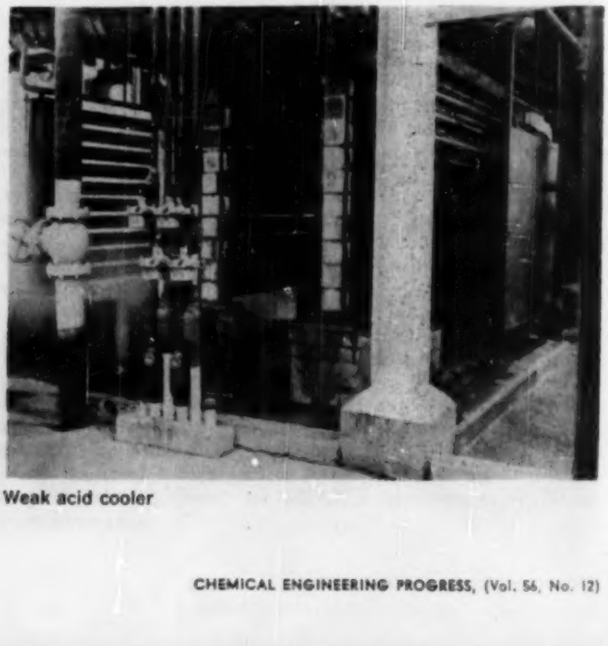
Over-all material balance around absorber (lb./stream-hr.)

Component	Feed gas in	Weak acid in	Total in	Strong acid out	Vent out	Total out
HCl	2,300	2,588	4,888	4,865	23	4,888
H_2O	..	10,352	10,352	10,320	32	10,352
Inerts	867	..	867	..	867	867
Total	3,167	12,940	16,107	15,185	922	16,107

Figure 2. Closeup details of some of the prinicipal equipment of the recovery unit.



Top of absorber



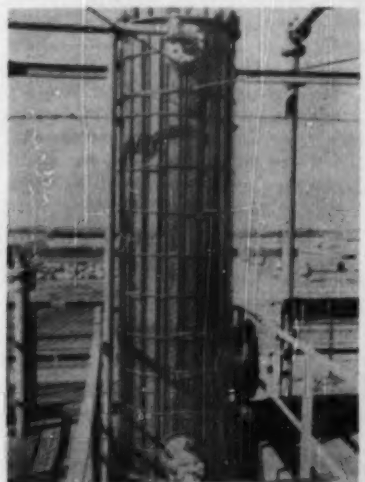
Weak acid cooler

. . . An internal material balance is prepared based on the assumed absorption split in the three sections as shown in Table 2.

Table 2. Internal material balance (lb./stream-hr.).

	Gas in	Acid in	Total in	Gas out	Acid out	Total out
Tails tower (*C*-1)						
HCl	592	2,588	3,180	23	3,157	3,180
H_2O	32	10,352	10,384	32	10,352	10,384
Inerts	867	....	867	867	....	867
Total	1,491	12,940	14,431	922	13,509	14,431
Temperature, °F	125	110	....	110	150	....
Upper absorber (*E*-6)						
HCl	1,446	3,157	4,603	592	4,011	4,603
H_2O	32	10,352	10,384	32	10,352	10,384
Inerts	867	....	867	867	....	867
Total	2,345	13,509	15,854	1,491	14,368	15,854
Temperature, °F	110	150	....	125	125	....
Lower absorber (*E*-5)						
HCl	2,300	4,011	6,311	1,446	4,865	6,311
H_2O	....	10,352	10,352	32	10,320	10,352
Inerts	867	....	867	867	....	867
Total	3,167	14,363	17,530	2,345	15,185	17,530
Temperature, °F	80	125	....	110	110	....

C. An internal material balance is prepared based on the assumed absorption split in the three sections. Although the water content of the gas stream will change through the absorber, for simplicity it is assumed to be constant at 32 lb./hr. The internal material balance is given in Table 2.



Tails tower

D. Figure 6 presents the operating and equilibrium lines obtained from the above material balances and bases. This diagram clearly indicates the improvement in driving force $(p\text{-}p^*)$ obtainable from two cascaded falling-film absorbers over either an adiabatic countercurrent absorber or a single falling-film unit. An incremental calculation down each cooled section of the absorber is made to check the exchanger size assumed. The following equation is used:

$$\text{Pounds HCl absorbed} = Kg\ A\ (p\text{-}p^*) \qquad (1)$$

E. Beginning with the top of the upper cooled absorber (*E*-6), the molar gas flows are as follows:

Component	Mol/Hr.
HCl	39.6
H_2O	1.78
Inerts	54.1
	95.48

With this feed the mol fraction of the HCl in the vapor $= \dfrac{39.6}{95.5} =$ 0.416 at a total pressure of 1 atm. Thus, the partial pressure of HCl in the feed is 0.416 atm. From the internal material balance the weight fraction of the

$$\text{HCl in liquid} = \frac{3{,}157}{13{,}509} = 0.232$$

From a vapor pressure chart (9) the vapor pressure of HCl over 23.2% acid at 150°F is 0.028 atm. Therefore $(p_1\text{-}p_1^*) =$ $0.416 - 0.028 = 0.388$ atm.

The vertical dotted line 1-1 in Figure 6 indicates this driving force.

Take point 2 at a position 1.5 ft. down the absorber tube.

Assume $(p_2\text{-}p_2^*) = 0.354$ atm. Then avg. $(p\text{-}p^*)_{1\text{-}2}$ over the in-

$$\text{crement 1 to 2} = \frac{(0.388 + 0.354)}{2}$$

$= 0.371$ atm.

The vertical dotted line 2-2 in Figure 6 indicates this driving force.

Area for 1.5 ft. of tubes = 29.2 sq. ft.

Moles HCl absorbed = $Kg\ A\ (p\text{-}p^*)_{1\text{-}2}$

Then the HCl absorbed from point 1 to point 2 = (15) (29.2) (0.371) = 163 lb./hr. Based on the HCl absorbed from point 1 to point 2, a material balance can be made at point 2. (See table on following page.)

A heat balance is then made around

Reynolds

Bingeman

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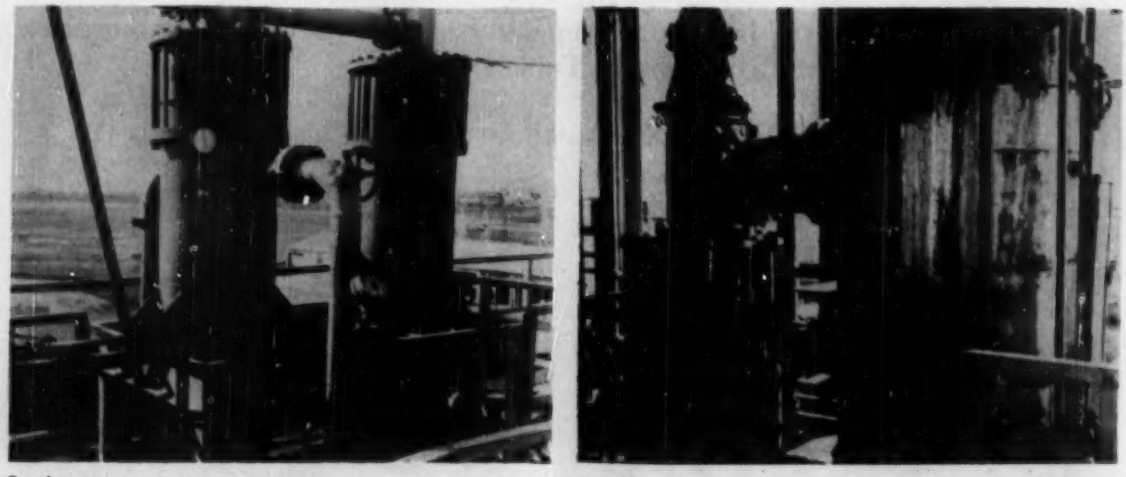
J. B. Bingeman is project engineering manager, Rexall Chemical. He spent ten years with Ethyl where his work included process design, evaluation and project work. Bingeman received a Ph.D. from Louisiana State.

Figure 3. More closeup details of principal parts of the recovery unit.



Condenser Reboiler

each increment and the heat transfer required for absorption and liquid cooling is checked against that available from the exchanger. Generally, heat transfer is not controlling.

A similar calculation is made for the remaining increments in the cooler-absorber. The calculations are repeated until the assumed exchanger satisfies the desired absorption for the unit. If the desired split is not achieved another exchanger size must be tried.

The final absorber design calculations led to two cooler-absorbers with 85 9-ft. tubes. Two exchangers with 110 9-ft. tubes were installed, however, to permit common sparing with the stripper condensers.

Material balance at point 2.

Liquid	lb./hr.	Gas	lb./hr.	Mol./hr.
HCl 3157 + 163 =	3320	1446 − 163 =	1283	35.2
H_2O	10,352		32	1.78
Inerts	–		867	54.1
Total	13,672		2.182	91.08

$$\text{Wt. fract. HCl } \frac{3320}{13{,}672} = 0.243 \qquad \text{Mol fraction HCl} = \frac{35.2}{91.08} = 0.387$$

$p_2^* = 0.033$ atm. $\qquad p_2 = 0.387\ (1.0) = 0.387$ atm.

$(p_2\text{-}p_2^*) = 0.387 - 0.033 = 0.354$ atm.

This checks the value assumed for $(p_2\text{-}p_2^*)$.

Figure 4. Portion of recorder chart showing relation between HCl content of feed gas and relative rate of feed.

Other calculations

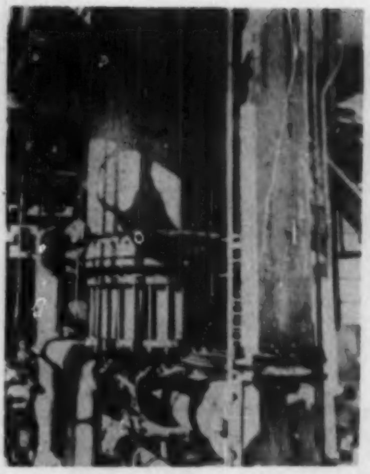
Tails tower. NTU's were calculated by means of a normal x-y plot after an assumed absorption split in the cooled absorbers had been checked out. Based on Ethyl experience, a value of 3 ft. was used for HTU.

Stripper. NTP's were stepped off on an enthalpy-concentration diagram for HCl and H_2O. A sample calculation of the theoretical plates is presented in Figure 7, showing eight theoretical plates required for stripping 32% acid to 22% acid. The HETP was obtained from laboratory and plant experience.

Stripper condensers. The stripper condensers were calculated by a stepwise calculation of film coefficients down the tubes. Equilibrium conditions were assumed at each point in the calculations. The Nusselt equation was used for condensate in the tubes and the normal shell-side equation as defined in Kern's "Process Heat Transfer" for flow across segmentally baffled tube bundles. Fouling factors of 0.003 were used for both inside and outside the tubes.

Stripper reboiler. The recirculation ratio was obtained by balancing the pressure drop through the reboiler against the hydrostatic driving force on the vaporizing fluid. When this ratio was obtained, the McAdams

Stripper



Reboiler

equation for flow inside tubes was used to determine the inside film coefficient. The outside steam film coefficient was assumed to be 1000 Btu/(hr.) (sq. ft.) (°F). Fouling factors of 0.001 were used for both inside and outside the tubes.

Weak acid cooler. The McAdams equation for flow over the outside of a drip cooler was used to calculate the outside film resistance. A fouling factor of 0.01 was added. The Dittus-Boelter Equation for fluids being cooled was used for the inside film coefficient. A fouling factor of 0.001 was used for the inside fouling.

Comparison of design and results

Data obtained during normal operation of the HCl recovery unit are compared in Table 3 with predictions in the original design and the literature. The original design predictions were, in general, conservative. An exception was the stripper reboiler heat transfer coefficient which turned out to be only 50-75% of design. Operating conditions in the absorber section have changed greatly since design. Feed compositions have risen from the design range of 45-65% HCl to 80-90% HCl. With the flows presently used, this results in 90-95% of the absorptio being done in the lower (first) absorber, most of the remainder in the upper absorber, and almost none in the tails tower. The vent losses with such operation are almost zero. The larger and smaller figures for Kg and U_o in the absorber represent the lower and upper absorbers respectively for this high HCl content in the feed.

The data obtained for the mass transfer coefficient fall between the correlation of Dobratz, et al (*3*) and the Gilliland correlation (*8*) as indicated in Figure 8. The data, in general, are in the range expected from

Table 3. Plant results vs. design and literature.

Item	Variable	Design	Plant	Literature	References
1. Cooled absorbers	Kg, lb./(hr.)(atm.)(sq. ft.)	15	3.6 (*E*-6)-21.4 (*E*-5)	8.5-220	*3, 4, 10*
	U_o, Btu/(hr.) (sq. ft.) (°F)	140	79 (*E*-6)-223 (*E*-5)	70-700	*2, 3, 4, 10*
	absorption, lb. HCl/hr.	1771 (54% gas)	2400 (80-90% gas)		
2. Tails tower	HTU, ft.	3			
	NTU	2			
	absorption, lb. HCl/hr.	454 (23% feed)	1 (1% feed)		
	HCl in off-gas, lb./hr.	18	2		
3. Absorption split predicted by design calculations	% HCl absorbed (calculated for 87.5 vol.-% HCl in feed				
a. tails tower	stock and Kg = 15 lb./(hr.)	0.3	0.04		
b. lower absorber	(atm.) (sq. ft.)	82.5	94.0		
c. upper absorber		17.2	5.96		
4. HCl stripper	NTP	5	8		
a. with packing	HETP, ft.	4	2.5		
	NTU	3.2	10		
	HTU, ft.	6.2	2		
	product, lb. HCl gas/hr.	1771 (28% feed)	2700 (32% feed)		
	weak acid, % HCl	20	19-23		
b. with turbogrid trays	NTP	7	7		
	actual trays	16	16		
	tray efficiency, %	44	44		
	lb. HCl/hr. from 32% acid	2700	3300		
	weak acid, % HCl	20	19-23		
5. Stripper condensers	U_o, Btu/(hr.)(sq. ft.)(°F)	85	44-130		
6. Stripper reboiler	U_o, Btu/(hr.)(sq. ft.)(°F)	510	248-385	421-550	*1, 6*
	flux, Btu/(hr.)(sq. ft.)	7400	13,500-8,700	26,000-33,000	*1, 6*
	ΔT, steam to process, °F	14.5	35	60-62	*1, 6*
7. Weak acid cooler	U_o, Btu/(hr.)(sq. ft.)(°F) fouled	25	54 (tower water)		
	clean	37			
8. Service factor	% of time plant is on stream	82	99		

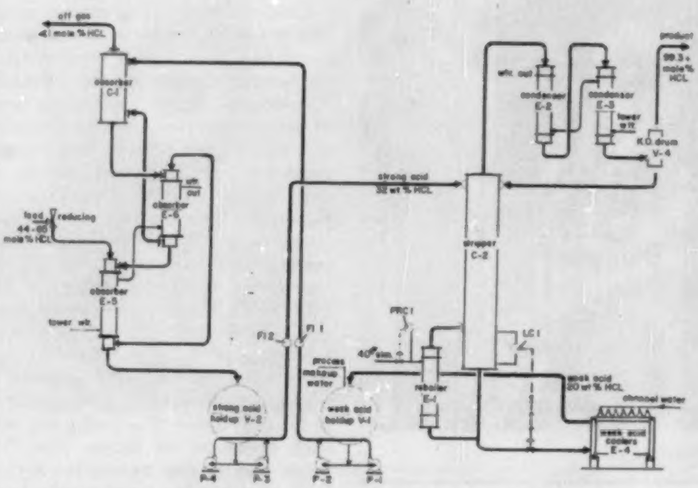


Figure 5. Process flow diagram of HCl absorber and stripper.

Feed comes into the HCl recovery unit at atmospheric temperature. It enters the upper head of an Impervite falling film absorber-exchanger (*E*-5). The gas flows cocurrently with a falling liquid film of aqueous HCl. Absorption of HCl gas into the liquid occurs as the two phases flow down the tubes, the heat of absorption being transferred through the walls to cooling water on the shell side. The liquid, strong in HCl, enters a rubber-lined holdup drum (*V*-2) upon leaving the lower head of the absorber-exchanger. The gas then enters the upper head of another falling film absorber-exchanger (*E*-6) identical with *E*-5. Here it is contacted cocurrently with another acid stream weaker than that in *E*-5. The liquid is enriched in HCl and upon leaving the lower head constitutes the liquid feed to *E*-5. Gas leaving the second cooled section enters the bottom of a packed Haveg 41 tails tower (*C*-1) where it is contacted countercurrently with a 20 wt.-% weak acid stream entering the top. Enriched acid from the tails tower feeds *E*-6. Prior to venting to the atmosphere, the off-gas is sent to a water scrubber not shown on the flow diagram. Equipment details are listed in Table 1.

Strong acid is pumped from the holdup drum into a stripper (*C*-2) in which the HCl concentration of the liquid is reduced almost to the azeotrope (about 20 wt.-%). A condenser system above the stripper, consisting of two water-cooled shell and tube exchangers (*E*-2 and *E*-3), removes the major portion of the water vapor present by cooling to 100°F. The cooled vapor passes through a K.O. drum (*V*-4) to remove entrained condensate. Heat for the stripping operation is supplied by 45 lb./sq. in. ga. steam to an Impervite shell and tube thermosyphon reboiler, *E*-1. The steam pressure is held by a pressure controller at a value chosen to give 20% weak acid. A level controller regulates the level in the bottom head of the stripper by adjusting the rate at which weak acid leaves.

The hot liquid leaving the bottom of the stripper flows by gravity through a drip cooler (*E*-4), cooled by *channel water, to a holdup drum (*V*-1). The liquid pumped from this drum is the weak acid feed to the tails tower (*C*-1). Liquid losses throughout the system, both from vaporization and from leakage, are made up by a process water addition to this drum. Because of the damping effect of the holdup volume of the strong acid holdup drum (*V*-2), the variation of strong acid concentration does not appreciably affect the operation of the stripper.

*Houston Ship Channel

the literature for the gas and liquid rate employed. Also included in Figure 8 for comparison are Ethyl data (*10*) on an $HCl\text{-}H_2O\text{-}H_2SO_4$ absorption unit.

The data presented here for the $HCl\text{-}H_2O$ system were obtained at constant liquid flows. All the data are observed to be consistent with the correlation by Dobratz.

The values of U_o for the absorber, 79-223 Btu/(hr.) (sq. ft.) (°F), fall in the range reported elsewhere (*4*) for impregnated graphite tubes, 140-175 Btu/(hr.) (sq. ft.), but are somewhat less than the values reported for tantalum tubes (*3*). The low coefficient of the upper absorber may be caused by coating of the insides of the tubes by material transferred from the stripper packing.

The amount of absorption in the tails tower was so small at the time of the test that the calculation of meaningful HTU and NTU values was impossible. The original design was based on a *Kg* of 15 in the cooled absorbers and an average HCl feed comparison of 54%. An absorption split was calculated as follows:

tails tower	– 25%
lower absorber	– 37.5%
upper absorber	– 37.5%

As can be seen from Table 3, experimental values for the amount of absorption varied widely from these figures as a result of the high HCl content of the feed stock–87.5% when the test data were taken. The absorption split which would have been predicted for this composition feed is much closer, though still somewhat lower, as a result of the low value used for *Kg*, 15 lb. HCl/(hr.) (atm.) (sq. ft).

The stripper section of the unit has been operated essentially as originally designed. The stripper itself has consistently performed better than design. Special attention to distribution and redistribution of liquid contributed to the improvement of HTU over design. Since replacement of the packing with Turbogrid trays, the capacity of the stripper has increased by 22% from 2700 to 3300 lb.HCl/hr. The trays have performed almost exactly as designed.

The stripper condensers have operated over a range of 50 to 150% of the predicted heat transfer coefficient. The coefficient for the stripper reboiler is 50-75% of design and also lower than reported in the literature (*1*, *6*). These lower values are probably a result of silica fouling from the stripper packing. However, it has been possible to exceed the design heat flux

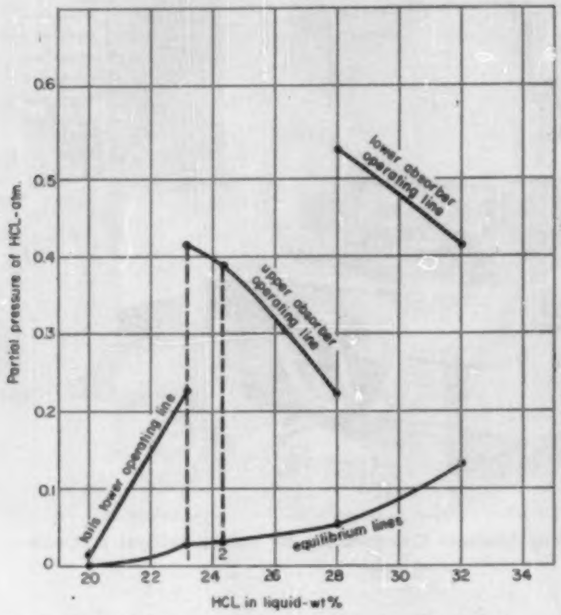


Figure 6. Absorption diagram for two cascade HCl absorbers with tails tower.

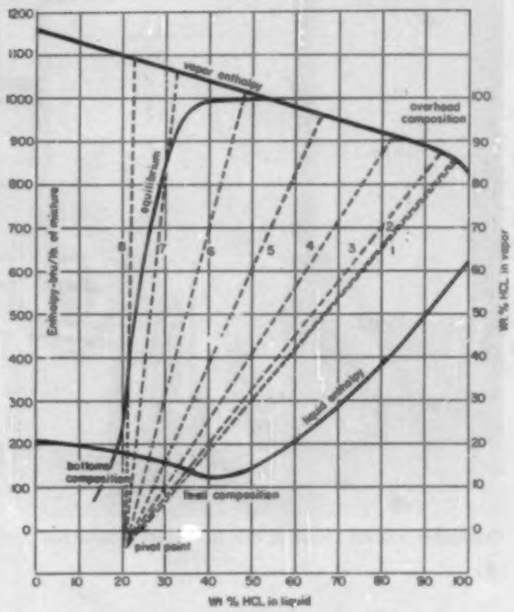


Figure 7. Enthalpy equilibrium concentration diagram for calculation of theoretical plates of HCl stripper.

by from 15 to 85% by raising the ΔT to 35°F.

The weak acid cooling heat transfer coefficient is significantly higher than even the clean design U_o. This is because the original calculation did not allow for evaporative cooling.

The plant service factor of 99% is a measure of the reliability of this installation and the excellent service it has given.

Acknowledgments

The permission of Ethyl Corporation to publish these findings is gratefully acknowledged as is the assistance of D. F. Agnew, E. H. Frederic, and R. G. Stirling in the accumulation of the data.

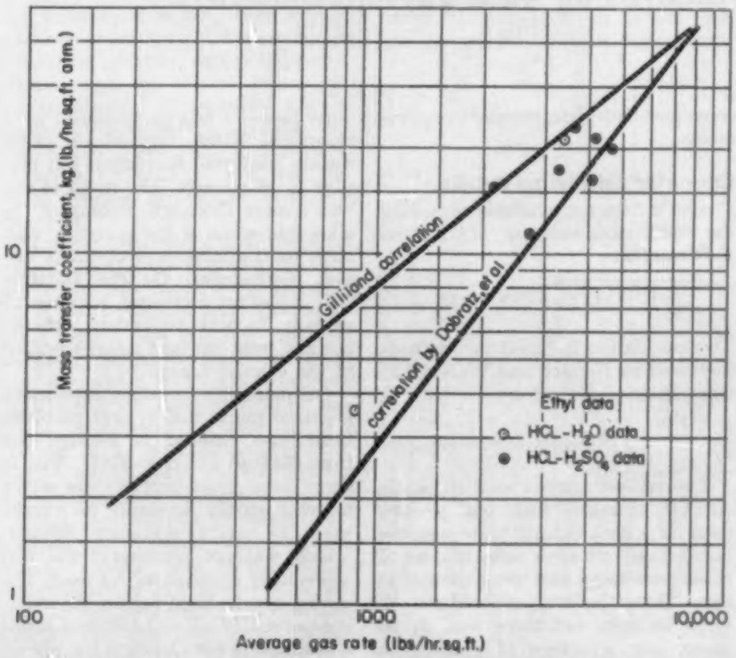


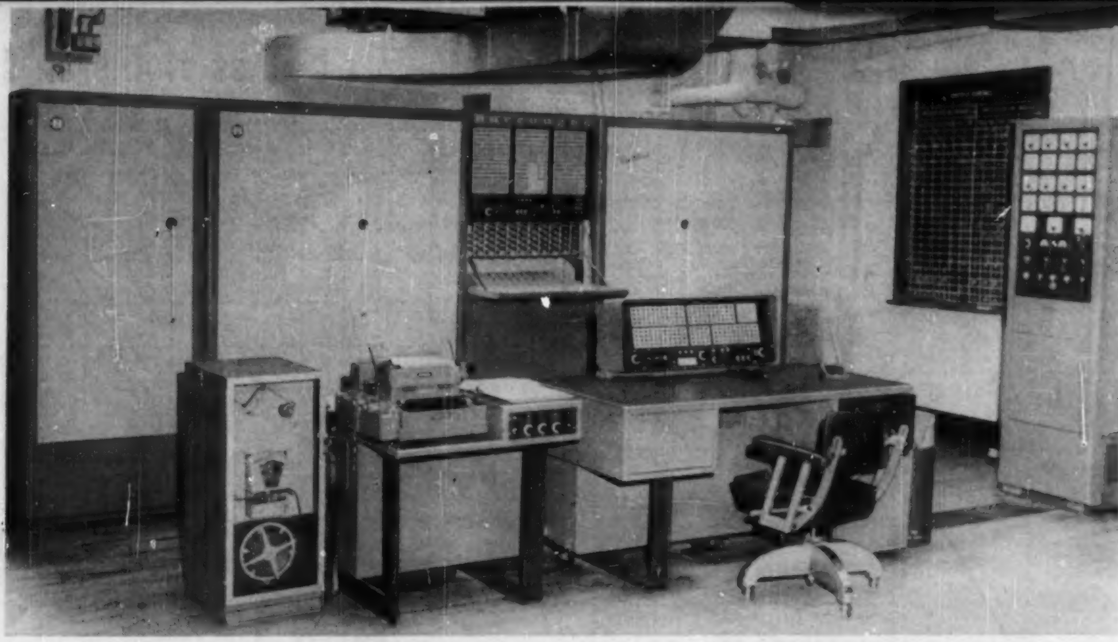
Figure 8. Correlation of mass transfer coefficients for HCl absorption.

Notation

A	area of absorbing film, sq. ft.
HETP	height equivalent to theoretical plate, ft.
HTU	height of a transfer unit, ft.
Kg	overall mass transfer coefficient, based on gas film, lb. HCl/(hr.) (sq. ft.) (atm.)
NTP	number of theoretical plates
NTU	number of transfer units
p	partial pressure of HCl, atm.
p^*	vapor pressure of HCl, atm.
U_o	overall heat transfer coefficient, Btu/(hr.) (sq. ft.) (°F)
ΔT	finite temperature difference, °F

LITERATURE CITED

1. Armstrong, W. F., "Construction Materials in Mannheim HCl Plant," *Chem. Eng.* *54*, 96 (1947).
2. Coull, J., C. A. Bishop, and W. M. Gaylord, "Hydrochloric Acid Production in a 'Karbate' Falling-Film-Type Absorber," *Chem. Eng. Prog.* *45*, 525 (1949).
3. Dobratz, C. J., R. J. Moore, R. D. Barnard, and R. H. Meyer, "Absorption of Hydrochloric Acid in Wetted-Wall Absorbers," *Chem. Eng. Prog.* *49*, 611 (1953).
4. Hatfield, M. R., and C. E. Ford, "Development of Karbate Materials and Their Application," *Trans. A.I.Ch.E.* *42*, 121 (1946).
5. Hunter, F. L., "Absorption of Hydrogen Chloride," *Trans. A.I.Ch.E.*, *37*, 741 (1941).
6. Lippman, A., Jr., "New HCl Rectifier Can Make CP Acid, Dry Gas, Solutions," *Chem. Eng.* *56*, 110 (1949).
7. Oldershaw, C. F., L. Simenson, T. Brown and F., Radcliffe, "Absorption and Purification of Hydrogen Chloride from Chlorination of Hydrocarbons," *Chem. Eng. Prog.* *43*, 371 (1947).
8. Sherwood, T. K., R. L. Pigford, *Absorption and Extraction*, McGraw-Hill Book Company, 2 Ed., 77. (1952).
9. Van Nuys, C. C., *Trans. A.I.Ch.E.* *39*, 663 (1943).
10. Unpublished Ethyl Corp. Report, (Dec. 31, 1957).



Computer shown above is the Burrough's Datatron 205 used by American Cyanamid Co. for solving catalyst problems.

Computer Design of catalytic reactors

Here is a manufacturer's viewpoint on customer services required in selling catalysts for water-gas shift converters.

CATALYST MANUFACTURERS are expected to supply prospective customers with services related to their catalyst materials. For example, the American Cyanamid Company, through its Refinery Chemicals Department, sells a line of catalysts for use in water-gas shift converters. The sale of these products always entails the estimation of catalyst requirements and, with ever-increasing frequency, of operating variables for the unit in question.

The potential user most often has fixed his process gas volume and composition, pressure, CO conversion required, inlet temperature and maximum allowable temperature, and the number of stages in his converter. He wishes to determine the conversion, inlet and exit temperatures, catalyst requirement for each stage, as well as quenching requirements between stages. Preferably all of these should be at the lowest total catalyst volume consistent with the customer's requirements.

Converter calculation details

Ample data are available regarding the equilibrium constant (*1*) for the shift reaction

$$CO + H_2O \underset{k_2}{\overset{k_1}{\rightleftharpoons}} CO_2 + H_2$$

The calculation is based on methods discussed by Hougen and Watson (*2*) using kinetics of the form

$$\frac{d(p_{CO})}{dt} = k_1 p_{CO} p_{H_2O} - k_2 p_{CO_2} p_{H_2}$$

The earliest method used to obtain catalyst estimates took one to two days on a desk calculator to compute one 3-stage converter using one set of those parameters that were allowed to vary. Stated limitations could not always be met, and there was, in no sense, any assurance of reaching a minimum catalyst volume. When the same problem was programmed on a Burroughs E102 computer, a single 3-stage converter calculation was possible in 15 minutes. The result of this was a more thorough probing of the allowable space of the operating variables for a minimum or optimum catayst requirement. On the Datatron 205, a 3-stage converter requires 20 seconds. In both computers, data input and print-out take a major portion of the elapsed times.

On examining previous experience, we have found that typical problems have been reduced in average cost from $300 to less than $100. Also, in these cases, every problem was solved to what would hopefully be considered a nearly optimum solution, which was not necessarily the case when hand calculation was used. This saving is calculated for the Burroughs computer E102. The additional saving due to use of the Datatron has not yet been estimated. It is likely to be rela-

R. M. DeBaun and S. F. Adler
American Cyanamid Co.

tively smaller in view of the greater number of trials being presently run on each problem. The problems attacked are also much more complicated.

Complexities of calculation

In our work on this problem, we have always attempted to design for minimum catalyst requirement, subject to any restrictions that might have been placed by the potential customer. While there is obvious merit to this attitude, it is not necessarily of maximum service to the customer as it does not consider, except indirectly, capital costs, the cost of steam, etc. The problem of efficient design, even assuming our criteria are correct, has been solved in what may appear to be an unelegant manner. We were, in effect, running experiments with our computer.

In general, the problem of design is complicated by the fact that the output of the i-th stage is the input to the $(i+1)$-th stage. Also, the calculation within any stage is certainly non-linear in temperature, composition, etc. These two aspects prevent the use of linear programming or any similar operational research devices. The use of a "steepest descent" (*3*) method would avoid the problem of the non-linearities inherent in the calculation. However, an uncritical minimization of catalyst requirements would, in many cases, abrogate the requirements of a customer with respect to temperatures, quench water amounts, etc. This is illustrated in the first sample problem.

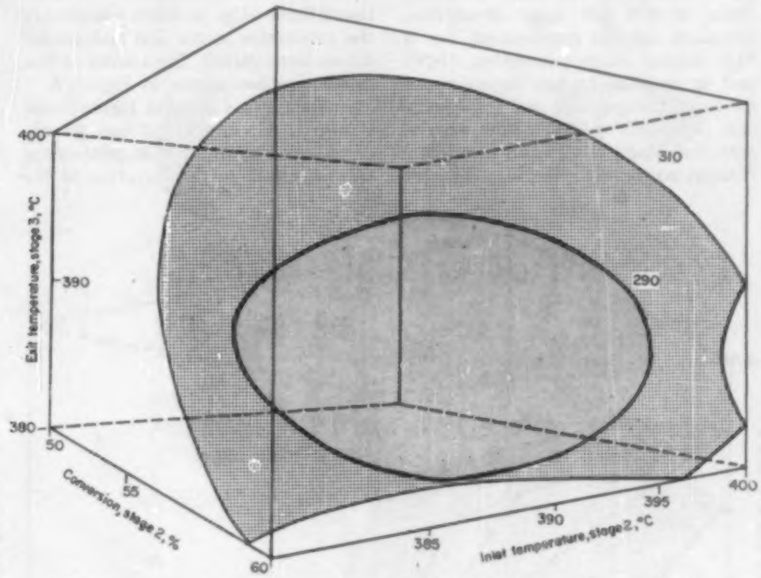


Figure 1. Analysis of catalyst requirements with 60% conversion in stage 1.

Sample converter problems

Typical catalytic design problems encountered are presented below.

Manipulation of four input variables. In a three stage problem, we varied conversion levels in the first and second stages, inlet temperature to the second stage, and exit temperature from the third stage. Inlet temperature to the first stage and steam to gas ratio were held constant. A large number of points in this space were determined and a second degree polynomial was fitted to the results of the calculation. The graphical

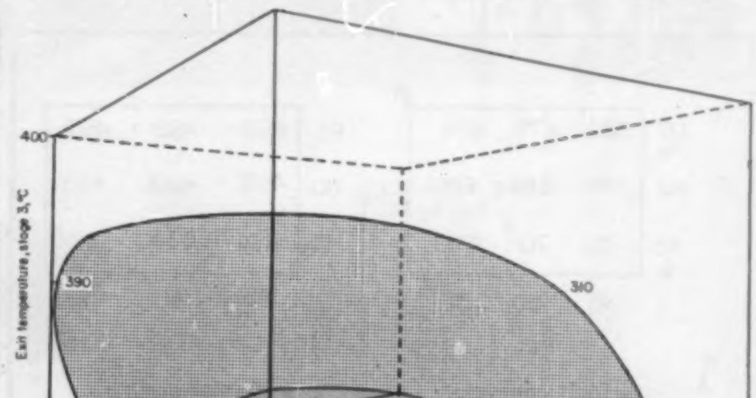


Figure 2. Analysis of catalyst requirements with 70% conversion in stage 1.

representation of this polynomial is given in Figures 1, 2, and 3.

The figures show a complex system in which selection of a different setting of one variable (first stage conversion) altered markedly the optimum settings of the other variables. Thus, at 60% first stage conversion, minimum catalyst requirement lies at high second stage conversion (60%) and at medium to low temperatures for second stage inlet and third stage exit (*i.e.*, 380°-400°C). However, at 80% first stage conversion, minimum catalyst requirement lies in a different operating region, namely at low second stage conversion (50%) and definitely low temperatures for second stage inlet and third stage exits (*i.e.*, at or below 380°C).

Customer requirement limitations. This feature is illustrated by an additional three stage problem where only the conversion in the first and second stages were varied. The results of this calculation are shown in Figure 4.

Imagining a Cartesian bicoordinate system in C_1 and C_2, it can be observed in Figure 4a that proceeding approximately in the direction of the indicated arrow will tend to reduce catalyst requirement further. However, a glance at Figure 4b shows that this course will almost surely increase exit temperature from stage No. 1 above 500°C, a limitation which is always placed by at least one customer.

Adler DeBaun

Stephen F. Adler is group leader, Oil Chemicals Research, in American Cyanamid's Industrial Chemicals Division. A Ph.D. in Physical Chemistry, he is author of seven papers. Adler is a member of ACS, Sigma Xi, and the Catalysis Club of Metropolitan New York.

Robert M. De Baun is group leader, Refinery Catalysts Research, Industrial Chemical Division, American Cyanamid. Author of 17 papers, he is a member of American Statistical Association. He has a Ph.D. from Fordham U.

Existing units. In making estimates for a shift converter which already exists, the catalyst volume is fixed and some other parameter becomes a variable. Usually total conversion is chosen as this variable. This problem is usually solved by a series of trial-and-error attempts at matching the design capacity of individual stages until the whole converter is fitted.

Interlocking units. A rarer type of problem is the one in which the potential user has two converters, usually of identical design, which may be operated in parallel or one at a time on a fixed flow of gas. The user will specify the expected conversion under each condition and will request those values of temperature and conversion under which a single set of catalyst volumes (stage-by-stage) will meet the two different conditions. This is, in effect, the solution of rather complex simultaneous equations.

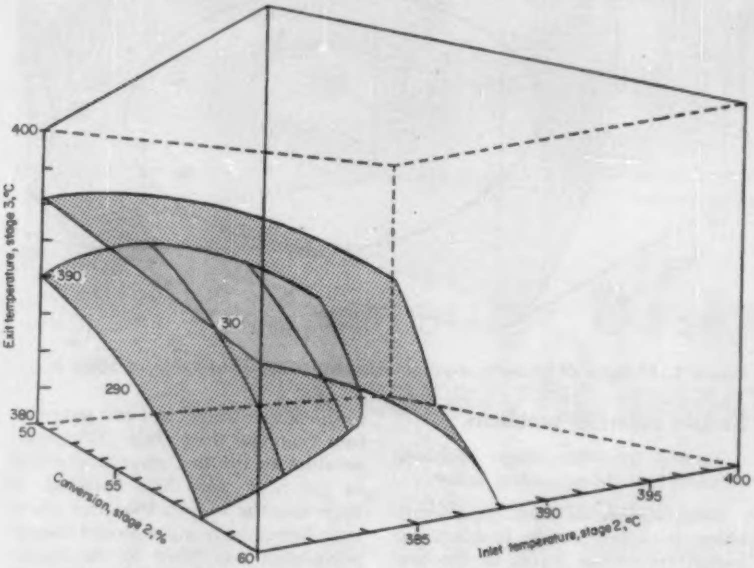


Figure 3. Analysis of catalyst requirements with 80% conversion in stage 1.

C_1 \ C_2	45	50	55
65	682	678	674
60	696	688	681
55	713	701	690

a- Total catalyst requirement, cu.ft.

C_1 \ C_2	45	50	55
65	492	492	492
60	483	483	483
55	474	474	474

b- Exit temperature of stage 1, °C

C_1 = % Conversion in first stage

C_2 = % Conversion in second stage

Figure 4. Catalyst requirements and temperatures in first and second stage.

ACKNOWLEDGMENT

The authors wish to acknowledge the generous help of D. B. Pennell and K. F. Kolb in translating the shift reaction calculations from their original form to computer language.

LITERATURE CITED

1. Rossini, F. D., *Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds*, Carnegie Press, Pittsburgh, Pa. (1953).
2. Hougen, O. A., and K. M. Watson, *Chemical Process Principles*, Vol. 3, J. Wiley and Sons, Inc., New York (1948).
3. Box, G. E. P., and K. B. Wilson, *J. R. Stat. Soc.*, *B 13*, 1 (1951).

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SUBJECT INDEX

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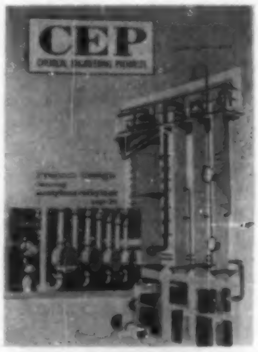

D

E

Subject Index *(continued)*

Subject Index *(continued)*

R

CEP
PLANT SITE SELECTION

Subject Index

(continued)

Abbreviations used: c.a., computer abstracts; N., news.

AUTHOR INDEX

industrial news

A.I.Ch.E. sponsors university research

Distillation study completed, several other areas under consideration by Research Committee.

THE FIRST A.I.Ch.E.–SPONSORED research project has been carried through to a successful conclusion, and the Institute's Research Committee is driving ahead hard to continue the program in important and useful areas of chemical engineering science.

This first project, carried out at three universities, involved the intensive study of the plate efficiency of distillation columns; the final report was published this summer.

Several proposals for future projects have been under recent consideration by the Research Committee:

Extraction—A proposal to evaluate the contact efficiencies of extraction equipment has been set aside on the ground that effective work in this area is already under way in a number of university laboratories and that, therefore, an organized project program is not needed at this time.

Machine Computations—In the opinion of the Research Committee, the proposal "to sponsor a central computations facility to correlate and calculate physical chemical data" might well be a more appropriate project for the A.I.Ch.E. Machine Computations Committee. The matter is presently under discussion between the two groups.

Equation of State—A proposal to sponsor a particular program to define the applicability of a new equation of state has been turned down on the grounds of "limited interest."

Distillation—A study of the transient behavior of distillation columns, believes the Research Committee, would be of wide interest to the chemical industry. It is realized that many companies are themselves working on specific problems in the control of distillation columns. However, it is thought that much of this work is so specific that it is not likely to contribute much to general knowledge of the subject or to elucidation of the fundamental principles involved. For this project, a sub-committee will formulate a specific research program to

continued on page 88

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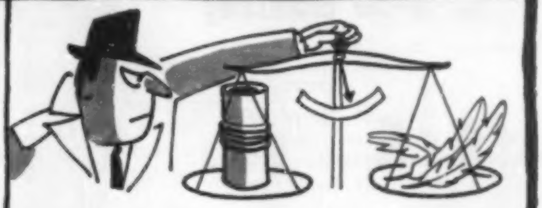

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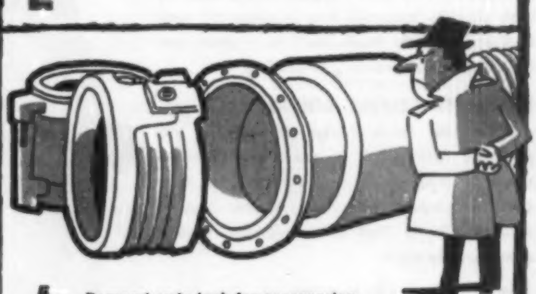

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Research

from page 86

be presented to the A.I.Ch.E. Council for action.

Non-Newtonian Flow—Here, two proposals have been presented; the first calling for a specific study of the mixing of highly viscous fluids, the second for research of a non-specified character in the general field of the mechanics of non-Newtonian fluids. The Research Committee has approved both projects as worthy of consideration, and detailed proposals will be prepared. #

No water shortage, says AISI expert

Alarmist prophecies not realistic —a dissenting opinion based on results of research study at Mellon Institute.

"AMERICA HAS NO CAUSE TO WORRY about a water shortage—either now or in the year 2,000," said R. D. Hoak, head of the American Iron and Steel Institute's Water Resources Research Project at Mellon Institute, in a recent talk.

Rejecting alarmist prophecies that the country faces a critical shortage, Hoak poined to a high-potential water resource that many of the experts "seem to have overlooked." According to Hoak, of all the water used in the United States, only about one-third is actually consumed. "Surface water," went on Hoak, "is used many times over as it flows from its sources to the ocean, and the true need is only the volume actually consumed by evaporation, incorporation in manufactured products, or otherwise temporarily eliminated from the cycle."

Breaking down total consumption by uses, Hoak estimates that there is 100 percent consumption only in rural use, 10 percent consumption in municipal and industrial withdrawals, 1 percent for steam-power generation, and 60 percent for irrigation. Total of these consumptions is only about 72 billion gallons per day, representing the supply of new water really needed to support all uses.

Against this demand, rainfall runoff to streams amounts to an average daily water supply of about 1.22 trillion gallons per day, from which water engineers believe it ultimately may be

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CEP COMPUTER PROGRAM abstracts

The Machine Computation Committee of the A.I.Ch.E. is interested in receiving program abstracts for publication as part of its program interchange activity. Details of this activity are given in the *Guide to Abstracts and Manuals for Computer Program Interchange*, which has just been revised based on experience during the first year the interchange has been functioning. Copies of the new *Guide* are available at no cost from the A.I.-Ch.E. in New York.

There are three rules for participation in the interchange program:

(1) Abstracts submitted for publication must follow the form shown in the *Guide*.

(2) The submitter of the abstract agrees to make available for publication a program manual, prepared as described in the *Guide*, should sufficient interest develop.

(3) Abstracts for publication, and all questions concerning published abstracts, must be sent to the Machine Computation Committee, c/o A.I.Ch.E.

Three manuals are now available: Line Sizing (Abstract 006–\$30), Liquid-Liquid Heat Exchanger Design (018–\$50), and Nonlinear Estimation (016–\$60).

Scheduled for publication in the next few months are manuals on: Multi-component Distillation (020), Plate-to-Plate Distillation for Complex Towers (017), Piping Flexibility (002), Bubble Cap Tray Design (010), Solution of Counterflow Water Cooling Tower (011), and Multiple Regression Analysis (028).

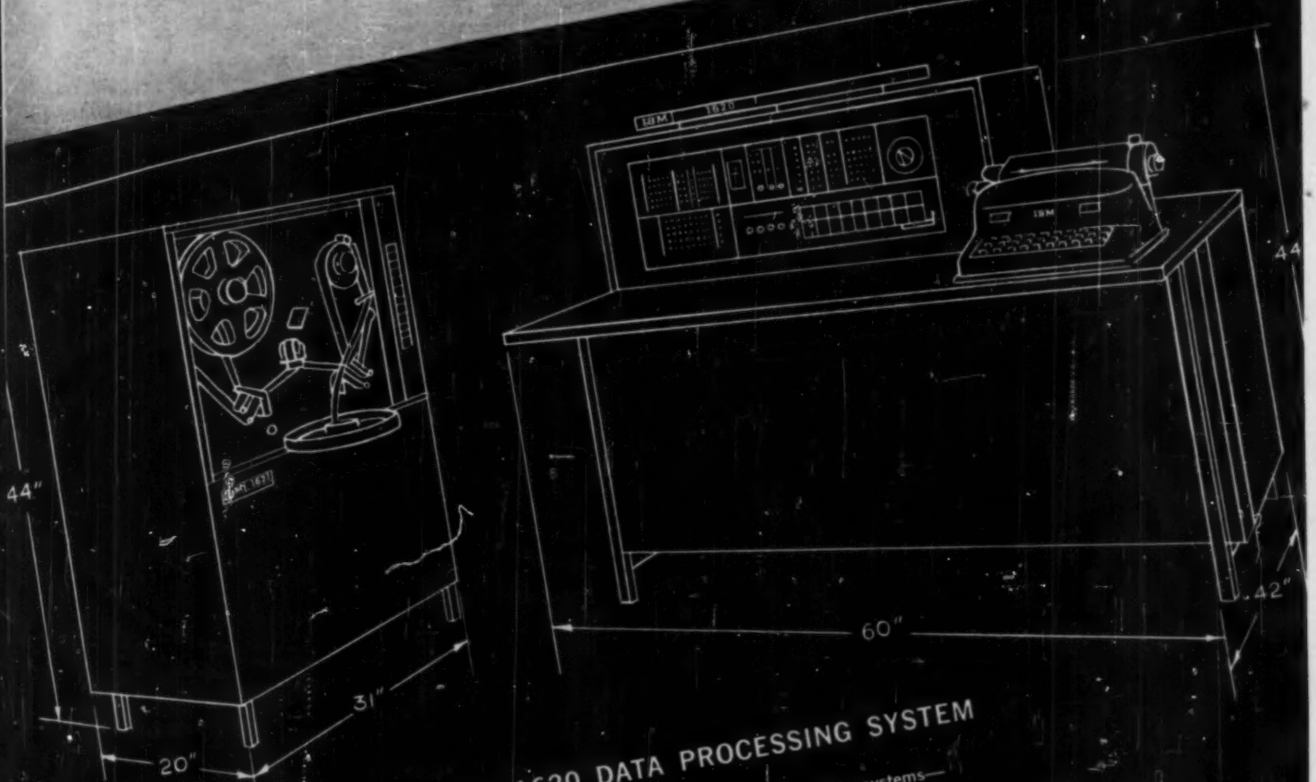
The decision on whether to have a detailed program manual prepared and published depends on the response to the corresponding abstract. Where sufficient interest has not been shown during the one-year period after publication of a given abstract, the submitter will be released from his commitment to prepare a manual.

The Committee has decided that because of lack of sufficient interest, manuals prepared to A.I.Ch.E. standards will not be published corresponding to several abstracts which appeared in CEP more than a year ago. These abstracts are listed below. In some cases, the submitter is willing to give a copy of the program and available documentation to interested parties. In such cases, the listing shows the program media and documentation which can be obtained and the person or organization to be contacted.

Those who are interested in having manuals prepared on some of the other programs, particulary those for which abstracts were published in late 1959 and early 1960, should notify the Committee promptly.

Publication of Computer Program Abstracts will be resumed next month.

Abstract No.	Program title	Computer	Documentation available	Available from
005	Critical shaft speeds	Univac I	....	....
007	Box cooler design	IBM 650	Punched cards. Program write up. Diagrammatic flow chart.	E. J. Sledjeski, Arthur G. McKee Co., 2300 Chester Ave., Cleveland, Ohio
008	Flange design	IBM 650	....	....
013	Curve plotting routine	IBM 704	Write up, source cards, and binary cards.	H. W. Crandall, Electronic Computer Center, Standard Oil Co. of Calif., 225 Bush St., San Francisco, Calif.
014	Tarner method for producing calculations	IBM 704	Write up, source cards and binary cards.	H. W. Crandall (see above)
015	Regression analysis	IBM 704	Program descriptions, symbolic cards and binary cards. Programs have SHARE designation SC-IEMR, SC-RAP and SC-BOP.	SHARE, for SHARE members
			Program write up and listing.	H. W. Crandall, (see abs. 013)
019	Specific impulse calculations	Datatron 205	....	....
021	Generalized flash sub-program	IBM 709	Program write up. Diagrammatic flow chart.	M. A. Albright, Phillips Petroleum Corp., Bartlesville, Oklahoma
022	Curve fitting	Datatron 205	....	....
023	Mass spectrometer calculations	IBM 704	Binary punched cards. FORTRAN and SAP listings. Data preparation instructions.	J. W. Judd, Research & Eng. Div., Monsanto Chemical Co., St. Louis 66, Missouri
024	Resistance temperature tables	IBM 704	Program description and FORTRAN listing. FORTRAN cards. Binary cards.	C. W. Woo, Applied Mathematics Section, Research & Eng. Div., Monsanto Chemical Co., 800 N. Lindbergh Blvd., St. Louis 66, Missouri
025	Response surface evaluation	IBM 704	Punched cards, binary or FORTRAN. Program write up.	A. W. Dickinson, Research & Eng. Div., Monsanto Chemical Co., St. Louis 66, Missouri



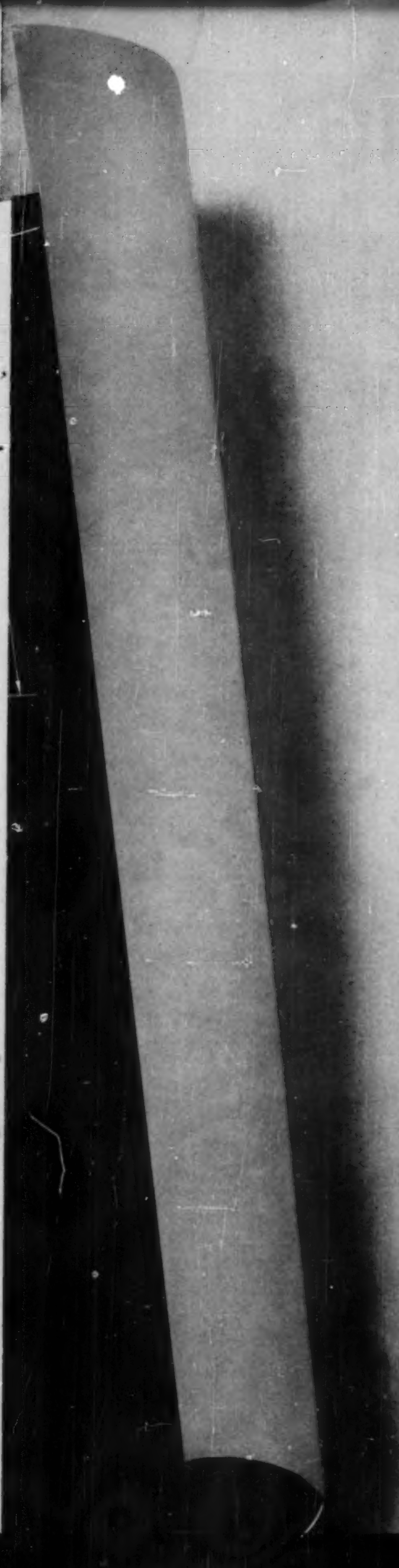
SPECIFICATIONS: IBM 1620 DATA PROCESSING SYSTEM

- Core storage—20,000 digits
- Automatic operation—stored programming
- High computing speed—20 microsecond machine cycle
- Powerful instructions with two data addresses
- Decimal and alphabetic
- Variable field and record length—any size numbers
- Advanced programming systems—Fortran and symbolic programming
- Compatibility with other computers through Fortran
- Simple console with logging features
- Self checking throughout
- Transistorized circuitry—compact, economical, reliable
- Paper tape input and output

The 1620 will meet technical computing requirements too complex for the conventional desk-type calculator. It provides many advantages of larger systems at a much lower cost. In addition, it can be used to support other data processing systems such as the IBM 650, 704, 705, 709, 7070 and 7090.

Information enters the system from the typewriter of the 1620 Central Processing Unit, or from the 1621 Paper Tape Reader. Output is to the typewriter or 961 Tape Punch.

Machine	Weight in lbs.	Current Requirements	Power cord	Interconnecting cable	Heat Load Specification BTU/Hr
1620	1,000	20 Amps., 115 Volts, single phase 10 Amps., 230 Volts, single phase 6.5 Amps., 208 Volts, three phase	10' 3-Wire for 115 and 230 Volts 10' 4-Wire for 208 Volts	10' signal 10' power	5,000
1621	280	—	—	—	2,000



No water shortage

from page 88

feasible to economically develop some 635 billion gallons per day.

Conservation still necessary

While the country has an ample national water supply, Hoak admits that many areas have too much or too little, depending on the season, and droughts may unbalance regional water economics. Local water-supply problems also are aggravated by increasing concentration of industry in the more heavily populated areas. Industry can make an important contribution, says Hoak. "There is sound authority for the prediction that increasing industrial reuse of water to 300 percent, from the current average of 100 percent, will permit twice the present output of goods without a significant increase in industrial fresh water demand." #

A new organic intermediates plant at Codogno, near Milan, Italy, is one of Montecatini's projects for the coming year. The plant will produce chemicals for use in varnishes and related products. On stream date is spring 1961. The new phthalic anhydride unit at the Montecatini subsidiary, ACNA, Cengio work's went on stream in October.

Chemical Engineering Faculties for 1960-61 is now available. The tenth annual edition of the publication lists a variety of information for over 135 schools in the United States and Canada. Included is information on types of graduate work offered, names of departmental faculty, accreditation, degrees granted. Prepared by the Chemical Engineering Education Projects Committee, A.I.Ch.E., the booklet is free to members. The charge for non-members is $3.00. Write to: A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

A gas cleaning plant supplied to the British firm Richard Thomas & Baldwins will be used in conjunction with a new oxygen steelmaking rotor furnace. The furnace is being supplied to the Redbourn Works, Scunthorpe, Lincs, by Gutehoffnungshutte. GHH awarded the contract for the plant to Chemical Construction. The unit is believed to be the first application in the United Kingdom of the Chemico P. A. Venturi Scrubber for the elimination of iron oxide fumes from an oxygen steelmaking plant. The installation is expected to be in operation early in 1961.

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FOR MORE INFORMATION CIRCLE NUMBERS

SUBJECT GUIDE to advertised products and services

EQUIPMENT

After Coolers (p. 118). Bulletin 130 from Niagara Blower gives details of the "Aero" after cooler. **Circle 18.**

Agitators, portable (p. 92). In 26 styles, sizes up to 3 hp. Bulletin 210 from Chemineer. **Circle 33.**

Castings, high-alloy (p. 20). Bulletin 3150 G from Duraloy gives complete technical info on fabrication and applications. **Circle 8.**

Centrifuges (p. 10). Technical info from Sharples on types designed to handle any processing requirement. **Circle 71.**

Centrifuge, pressurized (p. 8-9). Capacities to 5,000 gal./hr. Technical info from De Laval Separator on the SRG-214 Hermetic centrifuge. **Circle 29-1.**

Coils, heat exchanger (p. 99). Removeable-header feature permits complete drainability, easy cleaning. Bulletin R-50 from Aerofin. **Circle 1.**

Comparators, colorimetric (p. 117). Handbook from W. A. Taylor has 101 pages of technical data. Other useful info. **Circle 22.**

Compressors (p. 12). High pressure, air and gas. Catalog from Norwalk Co. **Circle 27.**

Computer, engineering (p. 90-91). Info from IBM on the 1620, low-cost desk-size computer for engineering calculations. **Circle 94.**

Controls, pneumatic (p. 92). Automatic or manual, trip or reset. Complete info on the "Mite" Series of packaged pneumatic controls from George W. Dahl. **Circle 30.**

Control Systems, electronic (p. 114). Brochure ECD-1 describes services and equipment offered by Flo-Tronics. **Circle 97.**

Control Systems, visual (p. 125). Data from Graphic Systems on the "Boardmaster" system. Booklet. **Circle 13.**

Conveyors, pneumatic (p. 100). Bulletin 143B from Spencer Turbine. **Circle 20-2.**

Couplers, quick (p. 125). Complete technical info from OPW-Jordan. **Circle 19.**

Crushers, jaw (p. 115). Capacities to 30 ton/hour. Bulletin 062 from Sturtevant Mill. **Circle 60-1.**

Crushers, rotary fine (p. 115). Capacities to 30 ton/hour. Bulletin 063 from Sturtevant Mill. **Circle 60-2.**

Demineralizers, packaged (p. 109). Complete technical details from Hungerford & Terry on "Two-Bed" and "Un-A-Bed" standard units. **Circle 64.**

Detector, voids (p. 86). Technical data and Bulletin from Tinker & Rasor give complete info on the M-1 Holiday Detector, designed for finding voids in protective coatings. **Circle 42.**

continued on page 94

MATERIALS

Caustic Soda (p. 27-28). New 36-page Booklet offered by U. S. Industrial Chemicals. **Circle 101-2.**

Defoamers, silicone (p. 98). New Manual on Foam Control offered by Dow Corning. **Circle 7.**

Dimethylamine (p. 107). Technical info and price schedule from The Matheson Co., Inc. **Circle 102-2.**

Gases, compressed (p. 107). Complete Catalog from The Matheson Co. Inc. **Circle 102-1.**

Heat Transfer Cement (p. 119). Bulletin 300 from Thermon Manufacturing gives properties, applications of non-metallic adhesive compound with highly efficient heat transfer properties. **Circle 32.**

Rubber, synthetic (p. 85). "Viton" synthetic rubber now improved to give twice former service life at 600°F, greater chemical resistance. Complete technical info from Du Pont. **Circle 67.**

Rust Solvent (p. 103). Info from Kano Labs on "Aerokroil" rust solvent. **Circle 72.**

Sodium (p. 27-28). Info from U. S. Industrial Chemicals on use of sodium in new hydrocarbon desulfurization process. **Circle 101-1.**

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Company ....
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City ....Zone.....State..........

DECEMBER 1960

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CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 93*

Dryers (p. 102). Complete technical details from C. G. Sargent's Sons on many types of tray and truck dryers. **Circle 75.**

Filtering Equipment (p. 29). Info from Industrial Filter & Pump on all types of equipment for liquid clarification, recovery, treatment. **Circle 61.**

Filter Paper (p. 32). Twenty-four-page Catalog 357 from Eaton-Dikeman gives complete details. **Circle 93.**

Flow Meters, magnetic (p. 26). Full details in Bulletin 20-14 from Foxboro. **Circle 83.**

Furnaces, multiple-hearth (p. 116). Bulletin 233 from Nichols Engineering & Research. **Circle 86.**

Gas Generation Systems (p. 110). Info from Gas Atmospheres, Inc. on packaged gas generation systems. **Circle 100.**

Heat Exchangers (p. 4). Bulletins HE and CI from Downingtown Iron Works describe fabrication and testing procedures used in manufacture of heat exchangers. **Circle 6.**

Heat Exchangers (p. 8-9). Technical info from De Laval Separator. **Circle 29-2.**

Heat Exchangers (p. 101). Proved engineering design, guaranteed job ratings, complete fabricating facilities. General Catalog from Engineers and Fabricators, Inc. **Circle 37.**

Heat Exchangers (p. 119). Booklet on Cost Engineering from Western Supply Co. **Circle 68.**

Heat Exchangers, standardized (p. 113). New bulletin 820 from Manning & Lewis gives technical details of full line. **Circle 17.**

Joints, expansion (p. 87). Technical info from Badger Manufacturing. **Circle 41.**

Kettles (p. 116). Info from Hubbert on kettles and tanks in stainless, nickel, Inconel, copper, Monel, titanium. **Circle 39.**

Kettles, processing (p. 118). Bulletin 600 from Bethlehem Foundry and Machine describes kettles for reaction, agitation, heat transfer, etc. **Circle 2.**

Manway, quick-opening (p. 103). Complete details in General Catalog from Lenape Hydraulic Pressing & Forging. **Circle 62.**

Mills, ball (p. 97). Paul O. Abbe offers Handbook of Ball and Pebble Mill Operation. **Circle 87.**

Mills, grinding, cage (p. 109). Handles wet, sticky, or gummy materials without plugging or slowing operations. Info from Stedman Foundry and Machine. **Circle 63.**

Mills, grinding, fluid-energy (p. 30). Complete info from Fluid Energy Processing & Equipment on "Jet-O-Mizer" mills, "Jet-O-Clone" dust collectors, testing and custom grinding services. **Circle 9.**

Mills, hammer (p. 115). Reduce to 20 mesh. Rates up to 30 ton/hour. Bulletin 084 from Sturtevant Mill. **Circle 60-4.**

Mixers (p. 95). Impellers can be raised and lowered with no process interruption. Bulletin LL-60 from Philadelphia Gear. **Circle 88.**

Mixer, continuous (p. 88). Bulletin RL-200 from Gabb Special Products gives complete details of the "Shear-Flow" mixer. **Circle 35.**

Mixers, portable (p. 114). Specially designed for small batch processes. Bulletin 530-E from Eastern Industries. **Circle 54.**

Mixers, portable (p. OBC). ⅛ to 3 hp, gear or direct drive. Bulletin 520 from Mixing Equipment. **Circle 96-2.**

Mixers, propeller-type (p. OBC). Complete technical data in Bulletin B-521 from Mixing Equipment. **Circle 96-1.**

Mixing Equipment (p. 22). Bulletins T-11 and T-1159 from General American Transportation. **Circle 28.**

Nozzles, spray (p. 6). Catalog 1 from Monarch Mfg. Works. **Circle 16.**

Ovens, industrial (p. 114). Bulletin 201-1 DT from Despatch Oven Co. gives details of new PLHD Series of preheating and drying ovens. **Circle 34.**

Packers, vibrating (p. 5). For boxes, cans, cartons, kegs, drums, barrels, up to 750 lb. Bulletin 401 from B. F. Gump. **Circle 12.**

Packing, tower, plastic (p. 36). Data from U. S. Stoneware on Pall Rings, available in polypropylene and high-density polyethylene, and on special order in PVC and polystyrene. **Circle 36.**

Piping, corrosion-resistant (p. 7). Info from Resistoflex on "Fluoroflex-T" piping products, specially processed of Teflon resins, for resistance to corrosives up to 500°F. **Circle 59.**

Preheater, air (p. 13). Brochure from Air Preheater Corp on "The Ljungstrom Air Preheater for Process Equipment." **Circle 66.**

Processor, thin-film, centrifugal (p. 108). Info from Kontro on the "Ajust-O-Film" continuous reactor. **Circle 73.**

Pumps (p. IFC). Standard or self-priming, heads to 345 ft., capacities to 3,500 gal./min. Bulletin P-4-100 from Duriron. **Circle 55.**

Pumps, canned (p. 11). Composite Bulletin 1100 from Chempump Div., Fostoria Corp. **Circle 5.**

Pumps, centrifugal, vertical-shaft (p. 113). Sizes from 1 to 16 in., capacities to 8,000 gal./min., heads to 230 ft. Pump Selector from Nagle Pumps. **Circle 57.**

Pumps, gear, steam-jacketed (p. 109). Bulletin 17-A from Schutte and Koerting describes complete line. **Circle 21.**

Pumps, jacketed (p. 117). Specially designed for handling viscous materials. New Bulletin J-57 from Hetherington & Berner. **Circle 38.**

Pyrometers (p. 109). Accurate temperature readings from minus 40 to plus 200°F in 3 to 5 seconds. Bulletin 2146C contains detailed specifications. Alnor Instrument, Div. of Illinois Testing Laboratories. **Circle 14.**

Rolls, crushing (p. 115). Rates to 87 ton/hour. Three types. Bulletin 065 from Sturtevant Mill. **Circle 60-3.**

Screen, vibrating (p. 8-9). Complete technical data from De Laval Separator on the "Syncro-Matic" screen classifier. **Circle 29-3.**

Scrubbers, fume (p. 14). Complete Catalog from Croll-Reynolds gives applications of jet-Venturi fume scrubbers. **Circle 3.**

Seals, mechanical (p. 96). Technical info from Durametallic on the "Dura Seal." **Circle 76.**

Separation Equipment, solid-liquid (p. 25). Complete technical info from Bird Machine. **Circle 58.**

Sulfur Burner (p. 115). Bulletin 100 from Chemipulp Process Inc. describes the Chemipulp-KC jet-type sulfur burner. **Circle 4.**

continued on page 96

SERVICES

Design and Construction (p. 18-19). Technical info from Lummus. **Circle 43.**

Design and Construction (p. 21). Details from M. W. Kellogg on its facilities for design, engineering, and construction in the U.S. and abroad. **Circle 65.**

Design and Construction (p. 23). Werkspoor (Netherlands) offers plants for ammonia synthesis, nitric acid, nitrolimestone, nitrophosphate, calcium nitrate, ammonium sulfate, urea. Technical data. **Circle 70.**

Design and Construction (p. IBC). Info from Ralph M. Parsons on world-wide design, engineering, construction services. **Circle 84.**

Fabrication, process equipment (p. 111). Info from Edw. Renneburg & Sons on dryers, coolers, separators in aluminum, other alloys. **Circle 56.**

Transportation, marine (p. 24). Info from National Marine Service on any type of water transportation. **Circle 40.**

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CEP'S DATA SERVICE—

Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 94*

Tanks (p. 116). Catalog from Groban Supply lists fluid and gas pressure tanks in stainless and carbon steel. **Circle 11.**

Tanks, wood, polymer-lined (p. 103). Data on "Polycel" linings, also Bulletins 1 through 5 on comparative costs, maintenance, chemical resistance. Wendnagel. **Circle 69.**

Thermal Conductivity Equipment. (p. 112). Data from Industrial Instruments Engineering on gas analyzer, sensing cells, power supply. **Circle 31.**

Vacuum Cleaner, industrial (p. 100). Catalog 155B "Industrial Vacuum" from Spencer Turbine gives complete details. **Circle 20-1.**

Valves, diaphragm, control (p. 34). Valve Enginering Data Catalog, Bulletin CV53 from Kieley & Mueller. **Circle 15.**

Valve Positioner (p. 114). Bulletin E-3560 gives complete details of Type 3560. Fisher Governor Co. **Circle 10.**

SUBJECT GUIDE
to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT

301 Air Conditioning Unit. A 60-page Bulletin from American Air Filter Co., Inc., contains entire new line of packaged central station air conditioning units.

302 Algebraic Compiler. A 32-page Manual from Bendix Corp. presents information for mastering the G-15 ALGO compiler.

303 Analyzer, amino acids. Brochure from Beckman Instruments Inc., describes Model 120 amino acid analyzer.

304 Analyzer-Monitor. Information concerning a new gas analyzer-monitor for monitoring missile fuel atmospheres from Industrial Instruments Eng. Corp.

305 Control System, pump and valves. Information from The Vapor Recovery Systems Co. describes the Varelectric, a new two-wire system for controlling electrically operated equipment.

306 Controls, valve. Bulletin 21-60 from Philadelphia Gear Corp. presents information on type P-2 and P-3 Limitorque valve controls.

307 Conveyors, screw. Bulletin 83-A describes standard and industrial gas-tight screw conveyors from Sprout, Waldron & Co., Inc.

308 Couplings, corrosion-resistant. Details for a flexible couple made from 316 SS and glass-filled DuPont Teflon for pumps handling corrosive media from Eco Eng. Co.

309 Cryogenic System. Data Sheets for a new, self-contained miniature cryogenic electronic cooling system from Air Products, Inc.

310 Digital System. Information from Instron Eng. Co. describes the new dynamic digital system for high speed operations in quality control and statistical testing.

continued on page 98

MATERIALS

350 Alcohol, federal regulations. An up-to-date guide to federal regulations governing use of industrial alcohol is available from U. S. Industrial Chemicals Co.

351 Alkoxy Compounds. Data Sheets from The Harshaw Chemical Co. describes new aluminum and zirconium alkoxy compounds and gives uses.

352 Alkyl Bromides. Information on cetyl, hexyl, myristyl, and stearyl bromides available from Michigan Chemical Corp.

353 Alloys, high-temperature. A 20-page Booklet is quick reference for properties of complete line of Haynes Stellite Company's high-temperature alloys.

354 Catalysts. Catalog covering entire line of Girdler catalysts for the petroleum and chemical industry is available from Chemetron Corp.

355 Catalyst, urethane foam. Bulletin on properties of Fomrez catalyst for urethane foams from Witco Chemical Co., Inc.

356 Coating, corrosion resistant. Information available from Carboline Co. for Carbo Zinc 11 corrosion-resistant coating for process equipment.

357 Coatings, flame-plated. Bulletins from Linde Co. contain physical data and characteristics of flame-plated coatings.

358 Diallyl Phthalate Resin. A 26-page Booklet of properties, uses, and molding requirements of compounds based on Dapon from Food Machinery and Chemical Corp.

359 Ethers. A new 40-page Booklet from Union Carbide Chemicals Co. describes properties and uses of ethers and glycol diethers.

DEVELOPMENT OF THE MONTH

MULTIPLE POSITION CONTROL
(Circle 601 on Data Post Card)

A new electrical-mechanical servo device, called the Hanna-Powr Positioner, which automatically positions valves, float levels, hopper gates, etc. to any of several predetermined positions has been developed by Hanna Engineering Works.

The positioner is used in conjunction with various types of power mechanisms such as air or hydraulic cylinder, along with solenoid valves applied to operate a pipeline flow valve. By operating a remote position selector control switch, the valve will be opened or closed to any pre-set position. A return read-out signal indicates when this position has been achieved.

The above photo shows a positioner installed to regulate a pipe line valve by remote control. Adjustments of the limit switches to change the position-stops are made by simply loosening two screws and moving the switches. The control box is shown at the right.

For more information, Circle 601 on Data Post Card.

360 Material of Construction, Glasteel. A new 20-page Bulletin from The Pfaudler Co. presents the manufacturing steps, properties, uses of Glasteel.

361 Phthaloyl Chlorides. Data Sheet 827 on iso- and terephthaloyl chloride used as synthetic fiber raw materials from Hooker Chemical Corp.

362 Plastics. A 20-page Booklet gives a general description of the plastics produced by B. F. Goodrich Chemical Co.

continued on page 98

SERVICES

370 Causticizing, trends. Technical Reprint 3321 from Dorr-Oliver Inc. describes trends in continuous causticizing in the pulp and paper industry.

371 Computer Solution, phase equilibrium. A 7-page Report from Computer Systems, Inc. describes solutions to multi-component equilibrium problem with Dystac computer.

372 Corrosion Data. A chart from Nooter Corp. lists resistance of common materials of construction against variety of process media.

373 Ion Exchange. A 152-page Manual entitled "Duolite Ion-Exchange Manual" for technical reference is available from Chemical Process Co.

380 Services, design, fabrication. New Brochure from Chicago Bridge & Iron Co. shows products and services in nuclear, chemical, petroleum, cryogenics field.

CEP'S DATA SERVICE—

Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

MATERIALS *from page 97*

363 Polyethylene Emulsification. Report from Eastman Chemical Products, Inc. outlines procedure used to prepare non-ionic emulsions.

364 Polysulfide Rubber. New Bulletin PS-1 from Thiokol Chemical Corp. gives results of tests to define the resistance of polysulfide rubber to halogenated hydrocarbon fluids.

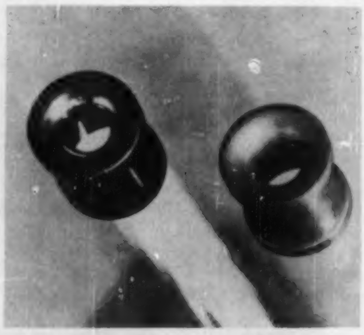
365 Refractories, fireclay. An 8-page Brochure from Harbison-Walker Refractories Co. gives features of some fireclay bricks.

366 Spherical Powders, metals and alloys. A new 8-page Bulletin from Linde Co. describes spherical powders produced by a new process.

367 Surfactants, anionic. Information from Antara Chemicals Div. of General Aniline & Film Corp. describes new line of anionic surfactants.

368 Sulfuric Acid. A 40-page data book includes uses, manufacture, properties, handling, analysis of H_2SO_4 from Allied Chemical Corp.

DEVELOPMENT OF THE MONTH



SUPER GRAPHITE

(Circle 603 on Data Post Card)

A series of high-density super graphites showing promise as high temperature materials to meet missile and space requirements are being produced by National Carbon Co.

The new recrystallized graphite, produced by a revolutionary hot-working process, has approximately two to three times the high temperature strength of conventional graphites. The super graphite has a highly reduced creep rate at 5300°F compared to conventional graphites which exhibit high creep at 4500°F, thus extending service 1000°F.

The density of the new material is 2.16 which closely approaches the 2.26 theoretical density. Conventional artificial graphites range in density around 1.85.

The photo above shows a rocket motor nozzle insert made from the recrystallized graphite at the left compared with a conventional graphite insert at the right. There appears to be no technological limitations to the sizes in which this material can be produced.

For more information, Circle 603 on Data Post Card.

EQUIPMENT *from page 96*

311 Disperser. Information available from Charles Ross & Son Co. describes new stationary tank type dispersers.

312 Drainers, liquid. A 12-page Bulletin from Armstrong Machine Works describes line of float type drainers for discharging liquids from gases under pressure.

314 Equipment, dust handling. A 44-page Book from Gelman Instrument Co. describes equipment for dust surveys, air pollution analysis, sub-micron filtration.

315 Equipment, process. A new 16-page Catalog includes data on process systems and vessels from Patterson Foundry and Machine Co.

316 Equipment, processing. A 16-page Bulletin G560 describes complete line of process equipment offered by Edw. Renneburg & Sons Co.

317 Evaporator, wiped-film. Bulletin 991 from The Pfaudler Co. presents features and uses of their wiped-film evaporator.

318 Feeders. Bulletin F-9 from Fuller Co. describes blow-through type revolver feeders for solid materials.

319 Filter, water. Information from Sparkler Mfg. Co. describes its new vacuum or pressure-type filter for clarification of process plant water.

320 Filter Chambers. Bulletin 401 contains details of corrosion resistant miniature filter chambers from Sethco Mfg. Corp.

321 Flanges, steel. Catalog of drop forged steel flanges from Harrisburg Steel Co.

322 Gasket, blowout-proof. Information on a new high pressure series of standard ASA flange gaskets available from Parker Seal Co.

323 Heaters, gas and electric. Bulletins from Despatch Oven Co. describes new line of gas and electric heaters.

324 Heaters, storage water. An 8-page Brochure introduces new line of storage water heaters from Niagara Weldments Inc.

325 Heat Exchangers. New Catalog of line of heat exchangers and selection charts from Old Dominion Iron & Steel Co.

326 Heat Transfer Equipment. Bulletin 800, a digest of heat transfer equipment, is available from Brown Fintube Co.

327 Hose. Bulletin 627 from Aeroquip Corp. serves as hose selection guide for use with 112 common materials.

328 Ovens, dielectric. Bulletin 60-E from Young Brothers Co. covers line of batch-type and conveyorized dielectric ovens and radio frequency generators.

329 Packed Column, auxiliaries. A 31-page Design Manual entitled "Support Plates Distributors and Hold-down Plates for Packed Towers" is available from The U. S. Stoneware Co.

330 Paint Finishing Systems. A 12-page Bulletin describing complete paint finishing systems from J. O. Ross Eng.

331 Pipe. Brochure from The Youngstown Sheet and Tube Co. contains data on Yoloy steel pipe.

337 Process Control, electronic. An 8-page Brochure describes closed-loop, all-electronic process control systems from Robertshaw-Fulton Controls Co.

339 Pump. Features of the new Coro-Vane, positive displacement pump with hydraulically actuated vanes available from Corken's, Inc.

340 Reaction Vessel, batch. Details for batch vessel for heating high purity materials from Glas-Col Apparatus Co.

341 Recorders-Indicators. New 48-page Electonik recorder Catalog from Minneapolis-Honeywell Regulator Co.

342 Regulators, pressure. Bulletin 132 gives details on Reliance type CBVA 400 and 600 pressure regulators from American Meter Co.

343 Tubes, condenser. Applications and advantages of integrally finned tubes available in Trufin Catalog from Wolverine Tube Div. of Calumet & Hecla, Inc.

344 Tubing, titanium alloy. Data Memorandum 27 describes titanium and titanium alloy tubing from Superior Tube Co.

345 Tubing, weight tables. A 16-page Brochure of weight tables for welded steel pipe available from Jones & Laughlin Steel Corp.

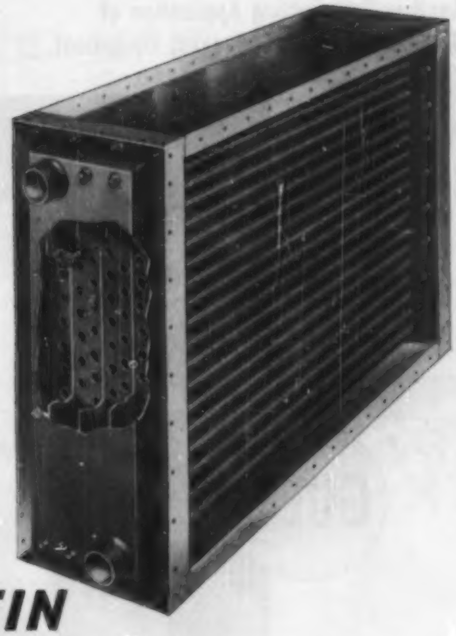
347 Valves, graphite angle. Data available for corrosion resistant piston-type angle valves using Impervite graphite from Falls Industries, Inc.

348 Valves, loading. Details of features and improvements of 417 and 418 loading valves from OPW-Jordan Corp.

349 Wire Cloth. Loose leaf specification Catalog of industrial wire cloth and screen from The Cleveland Wire Cloth and Mfg. Co.

A.I.Ch.E. Membership

Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 600 on Data Post Card.



A.I.Ch.E Candidates

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before January 15, 1961, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

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Crawford, R. J., *Claymont, Del.*

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Hanson, G. E., *Corpus Christi, Texas*
Hirschland, H. E., *Rochester, N. Y.*
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Loretta, F. B., *Mexico, D. F., Mexico*

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Metheny, D. E., *E. Chicago, Ind.*

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Smith, M. J., *Army Chem. Center, Md.*
Smoot, L. D., *Springville, Utah*
Snell, H. A., *Boise, Idaho*
Sorotzkin, J., *Ventura, Calif.*
Sterbenz, R. F., *Cleveland, Ohio*
Stevenson, W. R., *Lake Charles, La.*

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Tankersley, G. H., *College Sta., Texas*
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Thompson, T. L., *Atlanta, Ga.*

Uthoff, C. J., *St. Louis, Mo.*

van der Hoeven, W. R., *Dunbar, W. Va.*

Watkins, G. D., *Redondo Beach, Calif.*
White, J. S., *Bastrop, La.*
Wilcox, W. R., *Los Angeles, Calif.*
Wright, R. F., *Robstown, Texas*
Wurmbrand, H. G., *E. Orange, N. J.*

Affiliate

Anderson, A. B., *El Cerrito, Calif.*

Medwied, M., *Haifa, Israel*

Sloan, C. R., *Houston, Texas*
Sturchio, J., *San Francisco, Calif.*

A Japanese company to produce neoprene synthetic rubber will be formed by Du Pont and Showa Denko K.K. of Tokyo. The 18 million pounds a year plant will be located at Kawasaki, near an existing Showa Denko facility. Both Du Pont and Showa Denko are contributing capital to the jointly owned corporation, which will utilize process information and consulting services from du Pont.

Part of planned phthalate ester production at Monsanto, a new unit will add 50 million pounds to company capacity for Santicizer 160, one of the firm's largest selling proprietary plasticizers. Also in the mill on the new 650 acre site in Gloucester, N. J., are a 20 million pounds a year benzyl chloride plant, and a major anhydride plant. All three units are scheduled for early 1962 operation.

Catalytic Combustion Corp. has become a fully owned subsidiary of Universal Oil Products Co. through a mutual exchange of stock. They will continue to operate from their Detroit offices.

A five fold increase in capacity to produce active alumina is planned by Kaiser Aluminum & Chemical. A $700,000 production unit at its Baton Rouge, La., works will make Kaiser's spherical active alumina for chemical and petroleum processing industries.

Construction is proceeding on the titanium dioxide unit at Montecatini's Spinetta Marengo works, near Alessandria, Italy. When finished, the addition will increase production from 18,000 to 40,000 metric tons a year.

industrial news

A step up in research is planned at Pfaudler, with a $3¾ million technical center due for construction near Rochester, N. Y. The center will house the Engineering Service and Product Development Departments as well as Research. Three major areas of work will be in the ceramic, metallurgical, and organic fields.

A third major plant expansion now under way at Hodag Chemical will further increase production of the Chicago firm. Non-ionic esters, cationics and other surface active chemicals are expected to double in output when the additional equipment and facilities are added.

Latest addition to the ranks of on-site oxygen plants serving the steel industry is Linde's 500 tons a day facility at Great Lakes Steel Corp., Ecorse, Mich. The third major steel industry installation completed by Linde this year, the plant brings the company's total on-site capacity to 3623 tons a day. Shown are the heat exchanger and fractionating column. In the foreground are reversing heat exchanger, nitrogen regenerator, silencer, insulation silo and storage sphere.

A 50% boost in dimethyl terphthalate capacity is in the works at Amoco Chemicals. An expansion of the Joliet, Ill., plant is scheduled for completion in one year.

Work goes ahead on a urea unit at Solar Nitrogen Chemicals' Joplin, Mo., facility, which will contain both anhydrous ammonia and urea units. The project, to be operated by Atlas Powder, is due for completion in late 1962.

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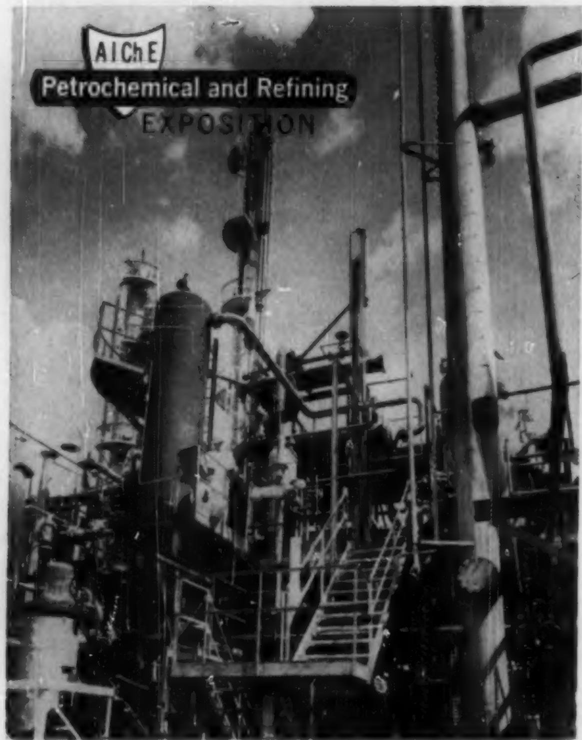
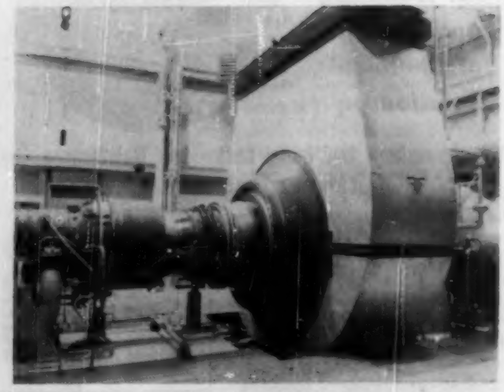
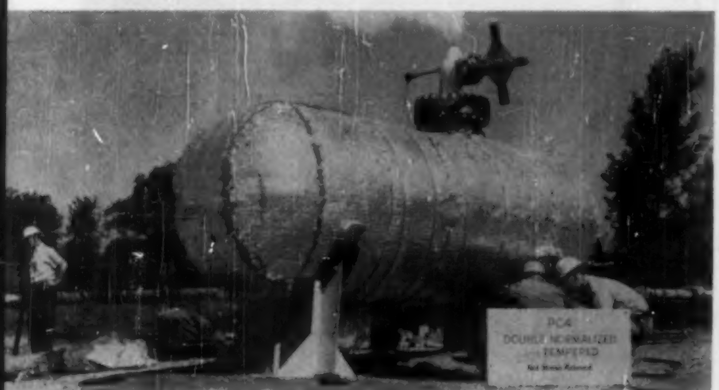


CELANESE CORP. OF AMERICA WILL build the nation's first full-scale commercial facilities for producing 1, 3-butylene glycol at its Bishop, Texas, plant. The new facilities will produce 25 million pounds of the plasticizer by a new process proved out in this semi-works unit. The worldwide petrochemical and petroleum refining picture will be reviewed at New Orleans, February 26-March 1, when the A.I.Ch.E. holds the first Petrochemical and Petroleum Refining Exposition in conjunction with its National Meeting.



GROUNDING OF THIS JET ENGINE has resulted in a new stationary power source at Columbia Gas Transmission Co.'s Clementsville, Ky., compressor station. The modified Pratt & Whitney J-57 engine is tied in with a specially-designed Cooper-Bessemer RT-248 gas turbine. Hot exhaust gas from the jet supplies raw thrust to drive the specially designed turbine. This, in turn, powers a large centrifugal compressor used on the gas system. Use of the jet engine reduces installation and power costs by about half. Additionally, downtime due to maintenance is expected to be cut considerably since a spare engine can be substituted in matter of hours.

Ready . . . set . . .



THIS DRUM, FABRICATED from 9% nickel steel and containing liquid nitrogen, finally ripped open but did not shatter under a load about six times the design stress. This and other tests, plus use in over 200 vessels, have proved out the newly-developed alloy for cryogenic applications. Special tests were jointly conducted for industry observers by International Nickel Co., Inc., developer of the steel, United States Steel Corp., and Chicago Bridge & Iron Co., fabricator of the test vessels at a special site at USS' Fairless Works, Penn.

going . . .

cep camera

ENGINEERS' NEW HOME nears completion in New York as workmen have reached the top, are already working on the interior.

400,000 BARRELS OF PROPANE will be stored in this granite cavern located 400 feet beneath Sun Oil Co.'s Marcus Hook, Pa., refinery. The total costs, including ¼-acre surface area, came to considerably less than \$3 million. Comparable above ground storage would take 600, 700-bbl. tanks and about 25 acres at an estimated cost of \$16 million. Fenix & Scisson, Inc., Tulsa, Okla., was contractor.

going . . .

. . . and what's left

MATHESON

Compressed Gas Notes

Organic Synthesis and Dimethylamine

Matheson has dimethylamine in a variety of cylinder sizes from 6 oz. to 125 lbs. Cylinder packing makes this low boiling (44.4°F.) compound more convenient to use in the laboratory. Anhydrous dimethylamine has a minimum purity of 99.0%.

Reactions

Some general reactions of dimethylamine which may stimulate your thinking on specific synthesis problems in your laboratory are listed below:

1. In the manufacture of sodium dimethyldithiocarbomate, which is also used as an intermediate to prepare other salts of dimethyldithiocarbamic acid and for the preparation of tetramethylthiuram disulfides.
   $(CH_3)_2NH + CS_2 + NaOH \rightarrow$
   $(CH_3)_2NCS_2Na$
   These types of compounds are used as fungicides and soil fumigants and as accelerators for the vulcanization of synthetic rubbers.

2. In the preparation of the systemic insecticides octamethylpyrophosphoramide and bis(dimethylamino) fluorophosphine oxide via bis(dimethylamino) chlorophosphine oxide.
   $4\ (CH_3)_2NH + POCl_3 \rightarrow$
   $[(CH_3)_2N]_2\text{-}P(O)Cl + 2(CH_3)_2NH.HCl.$

3. In the synthesis of local anesthetics via dimethylaminoethanol, which is prepared from dimethylamine and ethylene oxide.
   $(CH_3)_2NH + \overline{CH_2.CH_2.O} \rightarrow$
   $(CH_3)_2NCH_2CH_2OH$
   Dimethylaminoethanol is also an important intermediate in the synthesis of antihistamines.

4. For the preparation of quaternary ammonium salts.
   $RCl(R = C_{12}\text{—}C_{18}) + (CH_3)_2NH \rightarrow$
   $RN(CH_3)_2 \xrightarrow{C_6H_5CH_2Cl}$
   $RN(CH_3)_2(\overline{CH_2C_6H_5})Cl$

5. For the preparation of substituted hydrazines from halo amines, which are obtained from dimethylamine and halogens.
   $(CH_3)2NH + X_2 \rightarrow (CH_3)_2NX \xrightarrow{NH_3}$ —
   $(CH_3)_2NNH_2$

6. For inserting the dimethylaminomethyl group into appropriate compounds (Mannich reaction).
   $C_6H_5OH + CH_2O + (CH_3)_2NH \rightarrow$
   $2\text{—}HOC_6H_4CH_2N(CH_3)_2$

7. For the preparation of dimethylaminoalkyl chlorides, intermediates for the synthesis of tranquilizers, from alkylene chlorobromides.
   $(CH_3)_2NH + Cl(CH_2)_nBr \rightarrow$
   $(CH_3)_2N(CH_2)_nCl$

8. For inserting the dimethylamino group into compounds containing reactive halogen.
   $p\text{-}O_2NC_6H_4Cl + (CH_3)_2NH \rightarrow$
   $p\text{-}O_2NC_6H_4N(CH_3)_2$

Controls for Dimethylamine

Automatic regulator No. 12-240 is constructed of a heavy aluminum body, containing stainless steel parts, and a Butyl rubber diaphragm, for maximum corrosion resistance, and sensitive low pressure control, of the gas phase.

For accurate flow control of the liquid or gas phase, a type 51-240 needle valve may be used. This valve is available with a variety of outlets—hose end, ¼" NPT male or female, or ¼" SAE flare. Stainless steel needle valves for direct attachment to our lecture bottle size for laboratory use are designated as our nos. 32 and 59.

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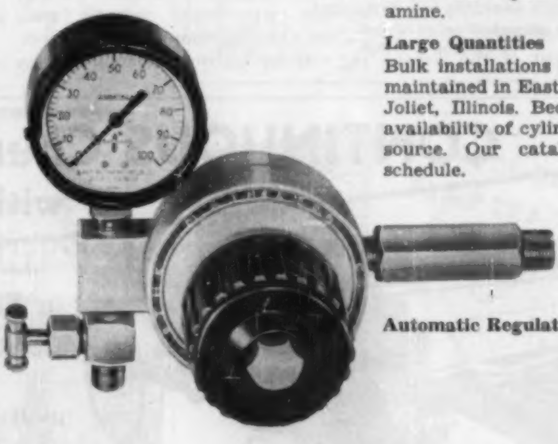

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Compressed Gases and Regulators East Rutherford, N. J. Joliet, Ill. Newark, Calif.

For more information, turn to Data Service card, circle No. 102

Awards highlight South Texas Annual Meeting

AWARDING OF PLAQUES highlighted the **South Texas Section** banquet held at the 15th Annual Technical Meeting in Houston in October. K. S. McMahon, section chairman, presided at the presentation where awards were made to section members for best papers published last year. *William N. Lyster*, Humble Oil, and *C. D. Holland*, Texas A.&M., received the awards for the Best Applied Paper, *Figure Distillation This New Way* (*Petroleum Refiner*, Vol. 38, No. 6 & 7). *A. E. Dukler*, University of Houston and consultant, was cited for Best Fundamental Paper, *Dynamics of Vertical Falling Film Systems*, (*CEP*, Vol. 55, No. 10).

Distinguished service award

The initial recipient of the Texas Section's Distinguished Service Award, W. A. Cunningham, University of Texas, presented the second award to W. B. Franklin, Humble Oil, an A.I.Ch.E. Council member. Purpose of the award is to recognize and honor the most outstanding chemical engineers for their long service to the profession and to the South Texas Section

Nearly 1000 attended the all-day meeting, which featured six technical sessions and three group sessions. Included were symposiums on saline water and on pollution. Eighteen papers were presented. In addition, a panel discussion was held on chemical engineering in Latin America. Industry exhibits represented sixty-six companies. General chairman of the meeting was Irv Liebson of Humble. Vice chairman was R. E. Driscoll, Texas Butadiene & Chemical.

W. B. Franklin, Humble Oil, was presented with the South Texas Section Annual Distinguished Service Award at the All-Day Meeting in October.

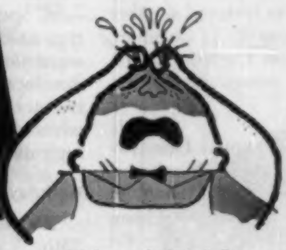
Western New York Award Dinner

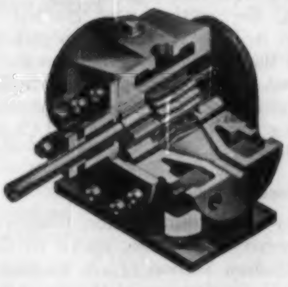
William J. Mitchell was honored by the **Western New York Section** (*R. L. Shaner*) at its annual Professional Achievement Award Dinner in November. Mitchell, senior development engineer with the Molecular Sieves Group, Linde Co., received the Ninth

continued on page 110

DON'T GIVE UP

when viscous liquids cause pumping problems . . .





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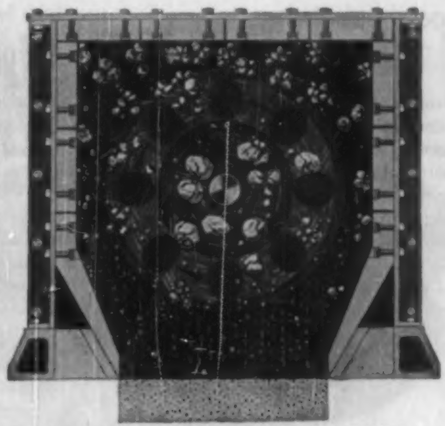

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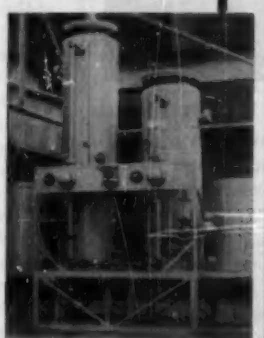

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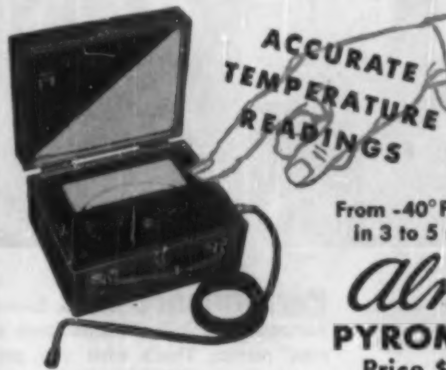

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The following thermocouple tips are available at \$35.00 each. Surface reading—air temperature—hypodermic needle—rigid immersion—needle and flexible wire type thermocouples.

This direct reading instrument has a full 6" mirrored dial of exact calibration. The movement is built with unusual precision, has jewel bearings and the very finest workmanship.

Each thermocouple is carefully constructed to obtain the exact circuit resistance; its calibration checked for resistance and also checked against known temperatures. Production is quality controlled within very fine tolerances to match the precision of the indicator movement. Bulletin 2146C contains detailed specifications.

Alnor INSTRUMENTS

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local sections

from page 108

Annual Award of the Section. He was cited for his "outstanding and loyal service to the local section and the national organization, and for his contribution to the profession of chemical engineering". Mitchell and his co-workers have made important contributions in early development work on Linde's molecular sieves. He also worked on the "rock drill" project which led to development of the company's jet piercing process and equipment. He holds several patents on this process. Mitchell was featured speaker at the dinner, where T. J. Coleman, vice president Union Carbide Development, made the presentation.

Northwest news

A very successful annual One-Day Meeting held by the **Pacific Northwest Region** in Longview, Washington, in October, featured Roland Voorhees, Union Carbide & Carbon, a director of A.I.Ch.E., as speaker. The meeting heard thirteen papers on various aspects of the chemical engineering field. Special attention was paid to the regional situation. Two of the papers were devoted to current and future developments in the chemical industry on the Columbia River. One paper covered the special topic, *Atomic Energy and the Pacific Northwest.*

Birthday in Chicago

The **Chicago Section** observed its 35th Anniversary at the November meeting. The oldest group in the Institute, the section was granted a charter in 1925. At this 225th gathering of the group, past chairman were honored. Thirteen were present for the festivities. Key speaker of the evening was Jerry McAfee, A.I.Ch.E. president.

Also meeting

Cecil H. Chilton, editor, *Chemical Engineering* magazine, spoke to the **Mid-Hudson Section** (*L. E. Rudisch*) on the *Vapor Pressure of Money*, at the October meeting . . . A brief history of the Eastman 910 adhesive was given to the **Atlanta Section** (*L. M. Wylie*) November. Speaker was Paul Von Bramer, Tennessee Eastman, Kingsport, Tenn. . . . The **Maryland Section** (*P. Messina*) heard Lucien Brouha, physiologist with Du Pont, report on a *Personnel Efficiency Study* . . . An illustrated talk on applications of photography in industry was highlight of the **Western Massachusetts Section.** Allie C. Peed, Jr., Eastman Kodak, was the speaker . . . Kodak was also at the **Rochester Section** (*J. S. Perlowski*) in November. William McFadden, who has studied creative thinking, asked *Why Not Put Your Imagination to Work?* . . . Corrosion, a subject always timely with chemical engineers, was under discussion at the **North Jersey Section** meeting. George T. Paul, International Nickel, was the speaker. The lecture was highlighted by a film on the fundamentals of corrosion. A tour of the chemical engineering facilities at U.S. Rubber Research Laboratories, Wayne, N.J., was also on the agenda. The tour ran the gamut from research labs to pilot plant units . . . Ion exchange occupied the **Kansas City Section** in October. The group heard G. D. Kortge, Dow Chemical, on basic concepts as well as some of the newer chemical application techniques . . . Should you be using titanium, and what are some of its engineering properties, was under discussion at **Western Massachusetts Section** in October . . . The **Northern West Virginia Section** (*L. A. Sears*)

heard K. R. Knoblauch, Minneapolis-Honeywell, on Economics and Automation in the Chemical Industry, at the September meeting . . . Three attorneys guided the **Fairfield County Section** through a hypothetical patent interference case. The cast was prepared by the American Patent Law Association and preserved on slides and tape. Presentation was by Herbert J. Evers, Patent Counsel, National Biscuit, and Evans Kahn, American Cyanamid. Moderator was Thomas G. Gillespie, Jr., Scientific Design.

More officers

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people in management and technology

Healy new A.I.Ch.E. head, McKetta elected VP, directors named

John J. Healy, Jr. has been elected president of A.I.Ch.E. for 1961. He is a member of the Corporate Planning Group, Monsanto Chemical.

A graduate of Harvard College with a B.A., he received a B.S.Ch.E. from MIT in 1921. Prior to joining Monsanto in 1929, Healy was with Merrimac Chemical, Everett, Mass., for eight years. He has served at Monsanto as assistant to the vice president in charge of research, development and engineering, and as director of the Development, Research and Engineering Division. The Planning Group, of which Healy is now a member, is responsible for all phases of long range planning for the company.

He has served two terms as director of the Institute, in '48-50, and in '57. A former representative of the Institute on the Engineering Manpower Commission, Healy has also served on several Institute committees. These include Nominating, Constitution and By-Laws, and Admissions. He is a former chairman of the Boston Section.

Also elected to A.I.Ch.E. office for next year was **J. J. McKetta**, vice president. McKetta is chairman of the Department of Chemical Engineering, University of Texas. He is chairman of the editorial board, *Petroleum Refiner* magazine. A member of the Board of Directors of five companies, McKetta is also author of three books and seventy-five technical articles.

New directors are: **R. R. White**, vice president, Atlantic Refining; **M. S. Peters**, U. of Illinois; **C. F. Prutton**, retired executive V-P, Food Machinery & Chemical; **R. J. McNally**, vice president, Garfield Chemical and Manufacturing. Re-elected were **J. H. Rushton**, treasurer, and **F. J. Van Antwerpen**, secretary.

Marlin P. Nelson has been appointed assistant director, Advanced Management and Methods Division, Sun Oil. He moves up from the post of senior chemical engineer in the division.

Gerald A. Forlenza has been named assistant general manager, American Cyanamid's Engineering and Construction Division. Forlenza has been with Cyanamid since 1958, when he joined the company as manager, Process Engineering Department. Before that, he was with Chemical Construction for eleven years.

Willis F. Thompson has been elected president of the United Engineering Trustees, Inc. In this capacity, he will be an ex officio member of the Board of Engineering Foundation. Thompson replaces **Andrew Fletcher,** past president of UET, on the Board.

Robert F. Stewart has been elected a vice president of Joy Manufacturing Co. He also takes over as general manager, Western Precipitation Division. He has been assistant general manager of the Los Angeles office of the Division for the past year.

David P. Muth is an addition to the legal staff of Shell Development. He is located at the Emeryville Research Center, as patent agent. He comes to Emeryville from Shell Oil's Norco refinery, where he was a technologist.

H. K. Arnold and **M. Rosenbaum** have been promoted to senior chemical engineers at Humble Oil & Refining's Technical Division, Baytown, Texas. Arnold works on improving process operations by using electronic computing machines. Rosenbaum handles problems in planning and development of projects in fuels and specialties manufacture.

L. F. Stutzman and **J. W. Tierney** are in Chile. As representatives of the University of Pittsburgh, they are teaching and assisting in development of the new graduate program at the University Tecnica Federico Santa Maria, Valparaiso. The program lead-

ing to a doctor's degree in Chemical Engineering, is believed to be the first of its kind in South America. Plans are underway to expand the program to include graduate work in other branches of engineering.

Robert Byron Bird, professor of chemical engineering at the University of Wisconsin, has received the George Westinghouse Award for 1960. The Westinghouse Educational Foundation Award goes to young engineering teachers of outstanding ability. Bird, a B.S. Ch.E., U. of Illinois, received his Ph.D. in Physical Chemistry. He studied at the University of Amsterdam on a Fulbright Fellowship. In 1957, he held a Fulbright Lectureship at Delft, The Netherlands. Bird is co-author of two books, *Molecular Theory of Gases and Liquids,* and *Transport Phenomena.* The results of his researches have been published in some 40 papers, both here and abroad. Active in A.I.Ch.E., Bird is a member of the Dynamic Objectives Committee.

Four men have been cited for best presentation of paper at the A.I.Ch.E. National Meeting held in Tulsa in September. They are **Jayarajan Chanmugam, E. S. Grimmett, A. M. Stover** and **D. S. Hoffman,** in that order. Chanmugam, lecturer in chemical engineering and assistant director, statistical techniques group, Princeton U., delivered a paper titled *Optimum Experimentation in the Process Industries.* Grimmett, Phillips Petroleum, talked on *Features of a Pulsed Continuous Counter-current Liquid-Solids Contactor.* Stover, U. S. Rubber, had the topic, *Queuing Theory Applied to Chemical Plant Operation.* Hoffman spoke on *Vaporization Equilibrium Ratios for Components Above Their Critical Temperatures.*

Thomas A. Burton has been appointed process industry sales engineer for Flo-Tronics, Inc. In this newly created position, Burton will handle sale and design of conveying systems and controls for the Minneapolis firm. He was formerly project engineer for Union Carbide Chemical.

Thomas E. Burns has joined Bird Machine Co. He will work in the new application engineering office at Walnut Creek, California. **William F.**

continued on page 115

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people

from page 113

White, who has represented the centrifugal and filtration equipment firm in the area for a number of years, will head the office.

conveying systems and controls for the Minneapolis firm. He was formerly project engineer for Union Carbide Chemical.

Jack W. Harris has been named Industrial Sales Manager of Hydromatics, Inc. He comes to the Bloomfield, N. J. firm from Rockwell Manufacturing, where he was assistant product manager, Nordstrom Valve Division. Harris is a past director of NACE.

Carl F. Prutton has been selected to receive the Perkin Medal by the Society of Chemical Industry, American Section. Prutton, recently retired executive vice president, Food Machinery and Chemical, continues with the firm as director consultant. He has an honorary degree from Case Institute, where he headed the Departments of Chemistry and Chemical Engineering from 1936-48. He has two other honorary degrees. Prutton received the Modern Pioneer Award from NAM, and the First Kirkpatrick Award for Management Achievement. He is author of numerous papers and holds more than 100 patents. Prutton was just elected a director of A.I.Ch.E. for the next 3 years. Presentation of the medal will be made at the Annual Perkin Medal Dinner in New York City in February.

Necrology

John J. Powers, Sr., vice president and member of the executive committee and board of directors, Chas. Pfizer & Co., until his retirement in 1945.

George Lloyd Allison, Sr., 70, retired manager of technical information, B. F. Goodrich Co. Allison had been with Goodrich from 1917 until his retirement in 1955. During World War II he served the U. S. government in the Office of Rubber Director, WPB. Again, in 1951, he was with NPA for nearly a year. He was past president of the Akron Rubber Group and a member of A.I.Ch.E. and ACS.

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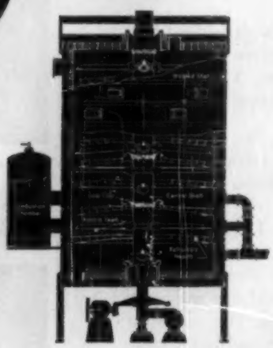

Nichols Herreshoff* and Bethlehem Wedge Multiple Hearth Furnaces are available with design modifications to prevent air infiltration and to permit maintenance of a reducing atmosphere in the hearth spaces. Either solid or gaseous reductant can be used.

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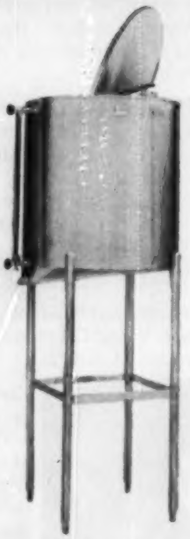

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See Page 386 in Chemical Engineering Catalog

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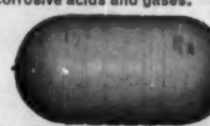
Steel tanks for the handling, storage and transportation of gases, beverages, fuels, hydraulic fluids and other liquids. Stainless steel tanks for corrosive acids and gases.



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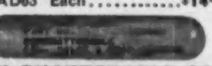

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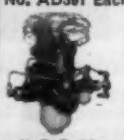

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future meetings

1961—MEETINGS—A.I.Ch.E.

● NEW ORLEANS, LA. Feb. 26-Mar. 1, 1961. Hotel Roosevelt. **A.I.Ch.E. National Meeting.** Gen. Arr. Chmn.: O. P. Wiedeman, Cyanamid, New Orleans, La. & H. E. O'Connell, Ethyl Corp., Baton Rouge La. Tech. Prog. Chmn.: A. L. Regnier, Cities Service R&D Co., 70 Pine St., New York 5, N. Y.

Free Forum-Informal Discussions of Possible Future Developments and New Research Areas—M. S. Peters, Univ. Ill., Urbana, Ill.

Brainstorming Technical Problems—G. C. Szego, Space Technology Labs., P. O. Box 95001, Los Angeles 45, Calif.

Kinetics of Catalytic Reactions—M. Boudart, Princeton U., Princeton, N. J.

Petrochemicals—Future of the Industry on the Gulf Coast—J. A. Sherred, Monsanto Chem. Co., St. Louis 66, Mo.

Filtration—F. M. Tiller, U. of Houston, Houston, Texas.

Settling—A. G. Keller, La. State U., Baton Rouge, La.

Future Processing Technology in the Petroleum Industry—K. E. Draeger, Humble Oil & Refining Co., Baton Rouge, La.

Education and Professionalism—R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 16, Ohio.

Mathematics in Chemical Engineering—R. L. McIntire, Mathematical Eng. Assoc., 3106 Sweetbriar, Fort Worth 9, Texas.

Evaluation of R & D Projects—L. A. Nicolai, 239 Parsonage Hill Rd., Short Hills, N. J.

Liquid-Liquid Extraction—R. B. Beckmann, Carnegie Tech., Pittsburgh 13, Pa.

New Petrochemical Processes in the Area—B. G. Caldwell, Dow Chem. Co., Plaquemine, La.

Materials of Construction—R. V. Jelinek, Syracuse U., Syracuse, N. Y.

Thermodynamics—J. J. Martin, Ch.E. Dept., Univ. Calif., L. A. 24, Calif.

Use of Probability Mathematics in Economic Evaluation—A. G. Bates, Atlas Powder Co., New Murphy Rd., Wilmington 99, Del.

International Chemical Industry—L. Resen, CEP.

New Chemical Processes—B. G. Caldwell, Dow Chem. Co., Plaquemine, La.

Selected papers—E. Manning, Shell Oil Co., Norco, La.

● CLEVELAND, O. May 7-10, 1961. Hotel Sheraton-Cleveland. **Joint A.I.Ch.E. National Meeting with Ch.E.Div. C.I.C.** Gen. Arr. Chmn: H. Pforzheimer, Jr., Standard Oil Co. (Ohio), Cleveland, O. Canadian Gen. Arr. Chmn.: W. D. Gauvin, McGill Univ., Montreal, Que. Tech. Prog. Chmn.: R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 16, O. Canadian Tech. Prog. Chmn.: A. I. Johnson, Toronto Univ.

Petrochemicals as Starting Materials for Polymers—L. F. Marek, A. D. Little, 30 Memorial Dr., Cambridge 42, Mass.

Fluid Mechanics—W. H. Gauvin, McGill Univ., Montreal, Que.

Laboratory and Pilot Plant Techniques—J. T. Cumming, School Eng., Fenn College, Cleveland 15, O.

Process Dynamics (Theoretical)—R. M. Butler, Imperial Oil Co., Sarnia, Ont.

Synthesis Processes for Isoprene—T. A. Burtis, Houdry Process Corp., 1528 Walnut St., Phila. 2, Pa.

Radioactive Materials for Process Control—J. R. Bradford, College of Eng., Texas Tech. College, Lubbock, Tex.

Process Dynamics (Applied)—L. M. Naphtali, Ch.E. Dept., Brooklyn Polytech., Brooklyn, N. Y.

New Synthetic Rubber Types—P. M. Lindstedt, Goodyear Tire & Rubber Co., Ch.E. Div., Akron 16, O.

Coalescence—R. Kintner, Illinois Inst.

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future meetings

from page 117

Tech., Chicago 16, Ill.

Management Criteria for Capital Investment—C. F. Prutton, Food Machy. & Chem. Co., 161 E. 42d St., New York, N. Y.

Chemical Engineering in Metal Refining—W. M. Campbell, Chem. & Met. Div., Atomic Energy of Can., Chalk River, Ont.

Heavy Chemical Mfr.—L. P. Scoville, Diamond Alkali, Union Commerce Bldg., Cleveland 14, O.

Applications of High Speed Photography—A. I. Johnson, Univ. of Toronto, Toronto 5, Ont.

Pulp and Paper—J. L. McCarthy, Univ. Washington, Seattle 5, Wash.

New Research Techniques—D. Hyman, Cyanamid, 1937 W. Main St., Stamford, Conn.

Mixing-Fundamentals—J. Y. Oldshue, Mixing Equipment Co., P. O. Box 1370, Rochester, N. Y.

Mixing-Applications—E. E. Ludwig, Rexall Chem. Co., 8909 West Olympic Blvd., Beverly Hills, Cal.

Cash Flow Methods in Economic Analysis—D. D. MacLaren, Esso Research & Eng., P. O. Box 215, Linden, N. J.

Heat Transfer—E. H. Young, Univ. Mich., Ann Arbor, Mich.

Selected Papers—D. J. Porter, Diamond Alkali, P. O. Box 348, Rsch. Center, Painsville, O.

Student Program—H. B. Kendall, Case Inst., 10900 Euclid Ave., Cleveland, O.

• LOS ANGELES, CAL. June 19-21, 1961. Univ. So. Cal. Campus. **1961 Heat Transfer and Fluid Mechanics Institute.** Sponsored by: Cal Tech, Stanford, Santa Clara, Southern Cal. and Cal. (Berkeley & L. A.) universities plus A.I.Ch.E., ARS, ASRE, Inst. Aerospace Sci, and SAE. Abstracts to Papers Comm. by Jan. 13, 1961; final papers by Mar. 3 to: R. L. Mannes, M. E. Dept., H. T. Yang, Eng. Center or M. Epstein, Eng. Center all at Univ. So. Cal.

• BOULDER, COLO. June 28-30, 1961. Univ. Colo. campus. **Second Joint Automatic Control Conference.** Sponsored jointly by ISA, A.I.Ch.E., AIEE, ASME, & IRE. Brief abstracts & rough draft of entire paper required before end of 1960. A.I.Ch.E. Prog. Chmn.: N. Gilbert, Ch.E. Dept., Univ. Cincinnati, Cincinnati 21, Ohio.

• BOULDER, COLO. Aug. 28—Sept. 1, 1961. **International Heat Transfer Conference.** Co-sponsored by A.I.Ch.E., ASME, and many others. More details in subsequent issues.

• LAKE PLACID, N. Y. Sept. 24-27, 1961. Lake Placid Club. **A.I.Ch.E. National Meeting.** Gen. Arr. Chmn.: B. I. MacDonald, Jr., G. E. Co., Waterford, N. Y. Tech. Prog. Chmn.: E. R. Smoley, 30 School Lane, Scarsdale, N. Y. DEADLINE FOR PAPERS: Apr. 24, 1961.

Control of Corporate Capital Investment Costs—W. K. Menke, Pittsburgh Chem. Co., Grant Bldg., Pittsburgh 19, Pa.

Management of Wastes at Nuclear Power Stations—W. F. Swanton, Pfaudler Co., Rochester, N. Y

World-Wide Sales Challenges in the 60's in the CPI—J. T. Costigan, Sharples Corp., 501 Fifth Ave., N. Y. 17, N. Y.

Mechanisms of Chemical Reactions—J. T. Horeczy, Humble Oil, P. O. Box 3950, Baytown, Tex.

Foamed Organic Materials—M. L. Nadler, Du Pont, P. O. Box 232, Penns Grove, N. J.

Chem. Engrg. in the Photographic Industry—A. K. Ackoff, Eastman Kodak, Kodak Park Works, Rochester 4, N. Y.

Techniques to improve Profitability of Petrochemical Processes—G. E. Hayes, Phillips Petro Co., Bartlesville, Okla.

Economics Theories Applied to Growth Industries—No Chmn.

Petrochemicals in the 60's—No Chmn.

Market Development in the CPI—L. B. Hitchcock, 60 E. 42 St., N. Y. 17, N. Y.

Bulk Fibrous Materials—R. M. Christiansen, Stearns-Roger Mfg. Co., Denver, Colo.

Economics of Equipment Selection—E. E.

continued on next page

continued

Ludwig, Rexall Chem. Co., 8909 West Olympic Blvd., Beverly Hills, Cal.

Air & Ammonia Plant Safety—G. R. Walton, Rohm & Haas Co., P. O. Box 672, Pasadena, Texas.

Selected Papers—No Chmn.

● NEW YORK, N. Y. Dec. 3-6, 1961. Hotel Commodore. **A.I.Ch.E. Annual Meeting.** Gen. Arr. Chmn.: L. J. Coulthurst, Foster Wheeler Corp., 666 Fifth Ave., N. Y. 19, N. Y. Tech. Prog. Chmn.: A. V. Caselli, Shell Chem. Corp. 50 W. 50 St., N. Y. 20, N. Y.

DEADLINE FOR PAPERS: July 3, 1961.

Fluidization—F. A. Zenz, Assoc. Nucleonics, Inc., 975 Stewart Ave., Garden City, N. Y.

International Chemical Industry—No Chmn.

U. S. Chemical Industry—No Chmn.

Utilization of Technical Personnel—No Chmn.

High Viscosity Fluids-Design Aspects—E. B. Christiansen, Univ. of Utah, Salt Lake City, Utah.

Physical and Transport Properties—A. A. Bondi, Shell Dev. Co., Emeryville, Calif.

Polymerization Kinetics and Catalyst Systems—No Chmn.

Transport and Kinetic Factors in Heterogeneous Catalysis—J. J. Carberry, Du Pont Co., Wilmington, Del.

Heat Transfer-Phase and Chemical Change Systems—G. T. Skaperdas, M. W. Kellogg, 711 Third Ave., N. Y. 17, N. Y.

Solid State Principles—H. G. Drickamer, Univ. of Ill., Urbana, Ill.

Flame Theory and Plasmas—H. M. Hulbert, Am. Cyanamid, 1937 West Main St., Stamford, Conn.

Solid State Applications—No Chmn.

Water Pollution—A. B. Mindler, Permutit Co., Birmingham, N. J.

Petroleum Processes—J. E. Walkey, Calif. Oil Co., Perth Amboy, N. J.

Petrochemical Processes—No Chmn.

Hydrometallurgy—G. H. Beyer, Univ. of Mo., Columbia, Mo.

Volatility Processing for Spent Reactor Fuels—O. E. Dwyer, Brookhaven National Labs., Upton, L. I.

Recent Advances in Ferrous Pyrometallurgy—S. V. Margolin, A. D. Little Inc., Acorn Park, Cambridge, Mass.

Rationale of Pilot Plants—J. T. Cummins, Penn College, Cleveland S. O. & G. W. Blum, 184 Ernest Dr., Tallmadge, O.

Polymer Handling Equipment—No Chmn.

Process Dynamics Control, and Simulation—A. S. Foss, Eng. Exp. Sta., Du Pont Co., Wilmington 98, Del. & D. E. Lamb, Univ. of Delaware Newark, Del.

Radiation and Furnace Design—H. J. Born, Born Eng. Co., Box 102, Tulsa, Okla.

Equilibrium Properties of Liquid Metals, Molten Salts, and their Vapors at High Temperatures—R. B. Filbert, Jr., Battelle Memorial Inst., Columbus, O.

Selected Papers—C. M. Thatcher, Pratt Inst., 215 Ryerson St., Brooklyn, N. Y.

Student Program—R. O. Parker, N. Y. U., University Heights N. Y.

1961—MEETINGS—Non-A.I.Ch.E.

● NEWPORT BEACH, CAL. Apr. 10-11, 1961. Aeronutronic Div. Ford. **1961 Spring Meeting Combustion Institute.** Abstracts (3) by Dec. 20, 1960 and review copies (2) complete by Jan. 20, 1961 to: M. Gerstein, Dynamic Science Corp., 1445 Huntington Dr., So. Pasadena, Calif.

In case you overlooked it

The Petrochemical and Refining Exposition is to be held in conjunction with the National A.I.Ch.E. Meeting in New Orleans, Feb. 26-Mar. 1, 1961. The theme will be the Chemical Engineer's role in design and development of petroleum and petrochemical facilities.

CLASSIFIED SECTION

Address Replies to Box Number care of:
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New York 36, New York

SITUATIONS OPEN

ENGINEERS–CHEMISTS

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Immediate opening with expanding northern New Jersey chemical company. Must have minimum of 5 years experience and B.S. degree in Chemical Engineering. Experience in resins, emulsions or acrylics preferred but not necessary. Salary commensurate with experience.

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BS or MS chemical engineer, 2 to 3 years experience for refinery technical service position. Assignment includes analysis and evaluation of unit operations to improve refinery realization and product quality. Economics and process design background desirable but not prerequisite. Submit personal resume to:

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Propellant Process Engineer

For process improvement and design of small-scale unit operation for solid propellant manufacture and rocket motor assembly, B.S. or M.S. in chemical engineering with up to 6 years experience in plant process technology.

Physical Test Expert

To direct and conduct test program involving physical characteristics of bonding systems, inhibitors, and other materials used in solid propellant rocket motors, and the correlation of physical and mechanical test data with propellant performance. B.S. to Ph.D. in mechanical or chemical engineering, physics, or chemistry, with theoretical background in polymer physical performance, and 4 to 10 years experience.

Radiochemical Engineer

To establish and operate a kilo-Curie-level hot laboratory. Includes technical direction of radio-chemistry projects in facility, as well as new business promotion aimed at attracting projects using radiological and radioactive materials and techniques.

Rocket Test Supervisor

To supervise assembly and loading of test rockets and customer units. Manage static firing facility, including scrutiny of static test setups to insure proper alignment and support, of instrumentation and calibration systems to insure data accuracy, and regular equipment checkups. Cooperate with development project engineers in test scheduling, review test results from computation group, and contribute to new equipment design. B.S. or M.S. in chemical, mechanical, or electrical engineering, an aptitude in mechanics and electronics, and considerable experience in production and electronic measuring instrumentation.

All positions require U. S. citizenship

If your qualifications and interests apply, please send resume of academic training and details of your experience to:

Clarence H. Weissenstein, Director
Technical Personnel Recruitment CEP

ATLANTIC RESEARCH CORPORATION
Alexandria, Virginia
(Washington, D. C. Metropolitan area)

SITUATIONS WANTED

A.I.Ch.E. Members

CHEMICAL ENGINEER—B.S., twenty years' experience. Imaginative leadership in supervision of plant start-up, design review, technical support to production, pilot plant operation, economic evaluations. Desire challenging, responsible assignment in plant technical service. Minimum $12,000. Box 9-12.

CHEMICAL & MECHANICAL ENGINEER—Graduate with many years of experience planning, directing development, applied research, process engineering, thermodynamics, high vacuum equipment experience, and commercial plants. Fluent French, German. Citizen. Box 10-12.

SUPERVISORY POSITION—Chemical manufacture. B.Ch.E., 1958. Three years' diversified experience which few my age can match. Have had supervisory training. Interested production or technical control. Eastern location preferred. Box 11-12.

CHEMICAL ENGINEER—B.Ch.E., registered, age 40. Twelve years' experience in process development, start-ups, troubleshooting, manager technical service. Principally inorganic. Desires position in similar work with greater challenge. Box 12-12.

CHEMICAL ENGINEER—B.Ch.E., twelve years' engineering and sales experience rating, testing and selling heat exchangers of many types, especially air-cooled. Some experience in branch sales office management; also devising shortcuts for rating. Box 13-12.

PLANT ENGINEER—B.Ch.E., P.E. Heavy experience: plant development engineering, production supervision, and maintenance in chemical process equipment, alloy plate fabrication, also chemical plant operations. Box 14-12.

SITUATIONS WANTED
A.I.Ch.E. Members

CONTROL SYSTEMS ENGINEER—B.Eng. (Chemical) 1950. Enterprising. Ten years' instrumentation and control systems experience in chemical industry. Particularly strong interest in computer control and comprehensive information procesing systems. Management interests ultimate goal. Challenging position sought with progressive firm in systems engineering and control field or in systems work with chemical or petroleum firm. Box 15-12.

SALES EXECUTIVE—Successful record licensing, engineering, construction sales petroleum and chemical industries. M.S.Ch.E., M.B.A. top schools. Twenty years' experience major oil company and leading engineer-contractors. Interested challenging opportunity V.P. or Sales Manager level. Box 16-12.

TECHNICAL SALES—M.B.A., Production Management, B.S.Ch.E. Valuable experience in management planning and computer applications to business. Seek position in technical sales or staff sales. Aggressive personality necessary for development into productive sales position. Box 17-12.

PRODUCTION SUPERVISOR—B.S.Ch.E., 1949. Experience in nylon, high energy fuel, synthetic rubbers, chemicals. Start-ups. Confidential security clearance. Fields of production, technical, project engineering. Seek responsibilities, higher level position in progressive company. Box 18-12.

CHEMICAL ENGINEER—Eighteen years' diversified experience in research and development, plant engineering and production management for petroleum, chemical and nuclear industries. Desire responsible position in East. Box 19-12.

CHEMICAL ENGINEER—Ch.E. degree, Age 31. Single. Seven years' varied experience in plant engineering, quality control, supervision, and process development. Desire position in Los Angeles in production supervision or process development. Box 20-12.

CHEMICAL ENGINEER—M.Ch.E., P.E. Eleven years' experience all phases heat transfer and process equipment. Manager R & D, responsible for new product development, basic heat transfer, fluid flow, physical property correlation. Large and small company experience. Box 21-12.

CHEMICAL ENGINEER—Age 34, M.S. Eleven years' experience, chemical, electronics and explosives. Process and supervisory experience, business oriented. Desires challenging position in management as manager or equivalent. Have the ability to get things done and can handle personnel. Box 22-12.

CHEMICAL ENGINEER—Nineteen years with leader in industry: project manager, design and construction, production, development. U.S. and overseas background. Languages. P.E. license. Anxious for challenge in another company. Anywhere. Box 23-12.

CHEMICAL ENGINEER—B.Ch.E., U.S. graduate, 23, single, fluent Spanish. Over two years' experience in Latin America. Manufacturing plant start-up, quality control. Economic studies of chemical process industries. Presently in U.S. Desire position of growth in Latin America. Box 24-12.

PRODUCTION SUPERINTENDENT—B.Ch.E., P.E. Excellent background. Production management and supervision, development engineering maintenance in chemical process equipment: alloy plate fabrication, and chemical plant operations. Heavy on scheduling, costs, labor problems and negotiations. Box 25-12.

CHEMICAL ENGINEER—S. B. One year experience in a laboratory in Waco, Texas. Supervisor was Stanley M. Tarnowski. Looking for position in a laboratory. A.C.S. member. Will work for $200.00 per month. Box 26-12.

CHEMICAL ENGINEER—B.Ch.E., five years' process engineering experience with petroleum refining including process design, control, and economic evaluation, and two years' process development experience with vinyl polymers. Request responsible position with domestic or overseas organization. Box 27-12.

CHEMICAL ENGINEER—B.S.Ch.E. 1958. Age 24, family. Two years' diversified process engineering experience in petroleum refining. In top quarter of graduating class. Tau Beta Pi. Desire challenging position with a growing processing firm. Box 28-12.

CHALLENGE WANTED—Ch.E., B.S., Notre Dame '58, M.S. Columbia '59. Army. Want process design position. No experience. N.Y.C., metropolitan area. Box 29-12.

(continued on page 122)

PROCESS DESIGN ENGINEER

Wanted Senior Process Engineer with 8 to 10 years' experience in petroleum refining processing. Experience must include diversified knowledge of petroleum, petro-chemical and related processes, process engineering design, process evaluation and economics, and some experience in technical service or operations. Experience with engineering and construction company desirable. Send complete resume to:

CATALYTIC
CONSTRUCTION CO.

1528 WALNUT STREET
PHILADELPHIA 2, PA.

DESIGN ENGINEER

Chemical Engineer with at least 5 years experience preferably in process engineering and design work in the chemical industry. Work includes economic and process calculations of inorganic and organic processes. Excellent opportunity with growth and advancement possibilities for the right man at the STAUFFER CHEMICAL CO., Richmond Research Laboratories, located in the San Francisco Bay Area just thirty minutes from downtown San Francisco.

Please send confidential resume and salary requirements to:

Mr. R. G. Campbell

STAUFFER CHEMICAL CO.
1375 SOUTH 47TH STREET
RICHMOND, CALIFORNIA

INSTRUMENT ENGINEER

BS-MS Chemical Engineer for position of Plant Instrument Engineer for chemical complex of over 600 different products. Work involves adaption of standard instruments to special plant processes: Development of unique measuring and control devices: Supervision of installation and maintenance by technicians: Instruction of technicians and trouble shooting on plant instrument problems.

Experience in instrumentation not necessary but candidates should be interested in instrumentation problems, electronics and supervision. Excellent advancement opportunities. Located in Midland, Michigan, a community of 27,000 with ideal family living, cultural and recreational advantages.

Send resume to:

TECHNICAL PLACEMENT DEPARTMENT
Box 468

THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

SITUATIONS WANTED
A.I.Ch.E. Members
(continued from page 121)

MANAGER—Twelve years' project engineer and engineering manager in design and development of fine chemicals, biologicals, and pharmaceuticals; twelve years' design and production in heavy chemical field; two years' industrial engineering. M.S.Ch.E., P.E. Box 30-12.

CHEMICAL ENGINEER—B.Ch.E., 1956, age 24. Two years' experience in laboratory and pilot plant design and studies, including development work with various high polymers. Desire N.Y.C. area. Box 31-12.

MARKETING/SALES MANAGER—Twenty-two years' experience in sales and marketing management, chemical equipment and materials. Strong on new product development and sales promotion. Good administrator, excellent writer, and speaker. Box 32-12.

MANAGEMENT POSITION—B.S.Ch.E., 1943 (Tau Beta Pi), M.B.A., 1949, Harvard Advanced Management Program, 1960. Age 38, family. Diversified background in management, process engineering, plant construction and operation. Desire challenging position in upper management. Prefer midwest or west, other locations considered. Box 33-12.

CHEMICAL ENGINEER—M.I.T. graduate, desire position as process or instrument engineering, Florida or Gulf coast preferred. Two years' experience batch polymerizations, three-and-a-half years instrumentation covering application, installation, start-ups, maintenance, training, parts stocking Box 34-12.

MANAGER DEVELOPMENT AND/OR ENGINEERING—Twenty years' experience, design and development of new processes and equipment in mineral, inorganic chemical fields. Aggressive leadership combined with ability for keen analysis of problems and successful project completion. Box 35-12.

PROCESS ENGINEER—B.S.Ch.E., 1952. Age 30. Desire responsible position offering professional growth in plant design group. Experienced in project engineering, and maintenance. Box 36-12.

(continued on page 124)

CHEMICAL ENGINEER

Wanted: a THINKING & WORKING chemical engineer whose primary interest is in getting jobs done well in terms of time & quality. We want a man EXPERIENCED in getting jobs done; in what line of business is not important. We offer an outstanding opportunity in a medium sized & growing organization which rewards a man who produces results.

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Chemical Engineers, B. S., or higher degree. Pilot plant development, semi-works plant operation, process design and economics, patent liaison and commercial development openings. Experience desirable, not required.

Please send résumé to:

G. L. Heller
Director of Development
Box 1562
Monroe, Louisiana

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(Agency)

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These items are listings of the Engineering Societies Personnel Service, Inc. This Service, which cooperates with the national societies of Chemical, Civil, Electrical, Mechanical, Mining, Metallurgical and Petroluem Engineers, is available to all engineers, members and non-members, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 60% of the first month's salary if a non-member, or 50% if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending application be sure to list the key and job number.

When making application for a position include eight cents in stamps for forwarding application to the employer and for returning when possible.

A weekly bulletin of engineering positions open is available at a subscription rate of $4.50 per quarter or $14 per annum, payable in advance.

Positions Available
New York Office

MANAGER OF PRODUCT DEVELOPMENT, degree in chemical engineering, chemistry or paper chemistry, with a minimum of six years' experience in technical sales, quality control or product development. Experience must have been acquired in paper or a closely allied field, e.g. packaging materials or textiles. Duties will include customer contact, technical writing for sales brochures, quality control and product engineering. Salary, $9000-$11,000 a year. Location, New Jersey. W-9844.

DESIGNER, chemical or mechanical engineering graduate, with at least five years' experience on design and layout of pressure vessels, piping and chemical processing equipment in petro-chemical or allied fields. Salary, $8000-$10,000 a year. Location, New York, N. Y. W-9838.

RESEARCH ADMINISTRATOR, Senior Chemical Engineer, Ph.D. desirable, to take over pilot plant studies, economic analysis in the chemical processes and unit operations as applied to agricultural commodities, i.e. cotton, cotton seed, peanut butter, etc. Salary, $12,000-$14,000 a year. Location, South. W-9752.

DIRECTOR OF RESEARCH, advanced degree in chemical engineering or chemistry, with supervision-managerial experience in research and development and work in formulations and processing coated plastics. Will plan and direct all product and process research and development; provide necessary technical services to manufacturing and sales; maintain and improve company's technical competitive position. Background in plastic-coated paper, coated plastic tapes, paint or plastic film manufacture desirable. Salary open. Location, southwestern New England. W-9726.

CHEMICAL PROCESS ENGINEERS with a minimum of three years' experience in design office on chemical process plant design and/or some operation with design, etc., for preparing process design calculations, flow sheets, etc. Salary, from $8400 a year. Location, western Pennsylvania. W-9718(c).

POLYMER CHEMIST, graduate in chemistry or chemical engineering, to 33; experienced with organic chemistry and with plastic films. Polyvinyl chloride and polyvinyl alcohol film for packaging purposes. Salary, $7800-$10,200 a year. Employer will pay fee. Location, Virginia. W-9703-C-8325.

ENGINEERS. (a) Research and Development Engineer, graduate chemical or chemist, with advanced degree or equivalent in practical experience, to develop and apply new and improved materials and processes for diverse line of built-up mica and flexible electrical insulation products. Background in synthetic resins desirable. (b) Process Engineer, graduate chemical or chemist, to assume diversified assignments in the production of mica tapes, sheets and molded parts. Responsibilities will include maintenance or process specifications, insuring product quality and implementing transfer of new products from R & D to production. Must be familiar with natural and synthetic resins, molding techniques and manufacturing processes involving hydraulic presses and treating equipment. Apply by letter giving complete details of experience, background and salary requirements. Location, Delaware. W-9662.

MANAGING DIRECTOR for a foreign subsidiary of a chemical manufacturing company. Duties would be those of a president of a 3 to 5 million dollar corporation. Responsibilities would include direction of production, purchasing, sales and finance. Location, Europe. F-9652.

SENIOR PROJECT ENGINEER, 30-42, chemical or mechanical graduate, with five to ten years' experience in petro-chemical, refinery or chemical plant design, installations and equipment changes. Must be capable of handling project from initial inception to completion, including process calculations, layout, equipment selection, supervision of construction, cost control and start-up. Salary, $8000-$9000 a year. Location, Illinois. W-9648.

TECHNICAL SALES REPRESENTATIVES, degree in chemical engineering or chemistry, with strong technical sales interest and capability. Some industrial sales experience in field desirable. (a) Plastics. Will consider mechanical graduate with some chemistry, for sales of plexiglas flat sheet and molding powders and polyester resins. (b) Textile Chemicals. Textile chemical degree preferred, to handle finishing agents, dispersing agents, desizing and sizing agents, coatings, etc. (c) Organic Chemicals. Organic chemistry, any degree, B.S., M.S. or Ph.D., also in bacteriology, for sales or sales development of organic chemicals, resins, coatings, emulsions, surfactants, etc. (d) Export Sales, same requirements as in a, b, c; some overseas living experience; foreign language facility. American citizen preferred. Salaried positions; company car available. Training in plants before territory assignment. On (d) will work out of country 50-60% of time. Company pays fees. Headquarters, Pennsylvania. W-9646.

CHEMICAL ENGINEER OR METALLURGIST, advanced degree preferred but recent applicable experience most valuable. Should have exprience in some of the following fields: High temperature metals and ceramics, joining of metals and ceramics, vacuum deposition of metals, combustion processes; for project involving conversion of heat to electricity. Salary open. Location, Connecticut. W-9625.

PROJECT ENGINEER, graduate chemical, with heavy chemical experience, to design and lay out ore processing equipment, steam power and heating facilities, plumbing and air conditioning. Salary, $8000-$10,000 a year. Location, eastern Pennsylvania, W-9598. Rewritten.

ENGINEER, Metal Finishing, graduate chemical, with a minimum of five years' metal finishing experience. Preferably organic enameling, plating, anodizing and finishing problems in general; particularly dealing with small components. Maximum salary, $11,000 a year. Location, Pennsylvania. W-9580(a).

San Francisco Office

PRODUCTION TRAINEE, chemical or mechanical engineering graduate, 26-30, qualified by academic or recent work experience to participate in a training program involving paper mill activities. Will lead to promotional work in the production division of a large manufacturing company or to transfer to other producing divisions in South America, Germany or Italy. Duties are demanding and the hours may be on a shift basis. Salary commensurate with experience. Location, Los Angeles, Cal. S-5702-R.

SALES ENGINEER, graduate chemical, electrical or mechanical, 29-35, with a minimum of five years' sales or process plant experience; to provide technical assistance to clients and promote the sale of instrumentation; to provide for control, actuators, direct reading or recording instrumentation for temperature, pressure, state of flow, etc. in process plants. For a manufacturer's district office. Salary, $7200 a year up plus company car and fringe benefits. Territory, Northwest area. Headquarters, Los Angeles. S-5696-R

CHEMICAL ENGINEER, graduate, with experience in field of explosive propellants and if possible electromechanical devices using these. Involves analysis, development testing, evaluation. Test instrumentation experience helpful. Requires U. S. citizenship. Salary open plus stock. Location, San Francisco Peninsula. S-5687-R.

CHEMICAL ENGINEERS, CHEMISTS, graduates at the Ph.D. level, about 35, whose general interest would be in petroleum and/or chemicals. Work will involve laboratory, process and operating departments, leading to staff operation or process assignments. Salary depends on experience and qualifications, but would be about $9600 a year minimum. Position with a major oil company. Location, southern California. S-5685-R.

RESEARCH ENGINEERS, B.S., M.S. or Ph.D. in chemical engineering, with none to five years' experience in unit and/or pilot plant operations. U. S. citizens. Salaries open. Location, southern California or Nevada. S-5683-R.

CHEMICAL PROCESS ENGINEER with three to ten years' experience in chemical, pertochemical or atomic energy plant design including the fields of polyolefins, rubber plants or other organic chemicals. Citizen preferred. Salary open. Apply by letter. Location southern California. S-5681-R.

INSTRUMENT ENGINEER, chemical, electrical or mechanical graduate, with five years' experience in refinery and chemical plant instrumentation. Experience in nuclear reactor instrumentation advantageous. Will engineer systems and write specifications for basic instruments, control systems, safety interlocks and relief systems for refineries, chemical plants and nuclear reactors. Salary, $7500-$10,200 a year. U. S. citizen. Location, southern California. S-5680-R.

SALES ENGINEER, graduate chemical, electrical or mechanical, 29-35, with a minimum of five years' sales or process plant experience; to provide technical.

DESIGNERS, chemical graduates, with a minimum of five years' experience in design of refinery, petro-chemical or chemical plants. Should be able to relate all phases of this type of work from the beginning to completion. Salary commensurate. Relocation allowance and employer will pay placement fee. Position with engineering builder. Location, San Francisco, California. S-5654-R.

PLANT ENGINEER, chemical graduate, to 40, qualified by recent experience to act as assistant on plant engineering staff, to assist in maintaining the continued operation of existing winery to help provide for plant changes and expansons. Should have knowledge of heat transfer, pasteurizing and sterilizing, chemical ion exchanges and related mechanical equipment. Salary, $7200-$9600 a year. San Joaquin Valley, California. S-5641-R.

SITUATIONS OPEN

Placement Bureaus

SITUATIONS WANTED
A.I.Ch.E. Members
(continued from page 122)

PLANNING MANAGER—Fourteen years' experience in business oriented planning and operations research, involving production, marketing and research. Authority on economic evaluation in process industries. Age 34. M.Ch.E., earning $15,000. Box 37-12.

CHEMICAL ENGINEER—B.S.Ch.E., 1949. M.S. Ch.E., 1954, age 36, family. Varied experience in organics and fertilizers including pilot plant development economics, process, and design. Supervision experience. Desire position with responsibility and advancement potential. Minimum salary $9600. Box 38-12.

CHEMICAL ENGINEER—B.Ch.E., age 32, married, veteran. Ten years' experience process development, pilot plant operations, project engineering, field engineering, very strong in plant start-ups, government contracts and specifications. Interested in food, chemical or process equipment manufacturing. Location unlimited. Box 39-12.

CHEMICAL ENGINEER—Fourteen years' successful experience all phases petrochemical manufacture. Includes co-ordinate supervision of multi unit operations. Desire assignment using exceptional combination of practical and technical talents. Box 40-12.

CHEMICAL ENGINEER—26, single, B.S.Ch.E., 1958. Three and one-half years diversified experience in CPI, including two years as process engineer for U.S. Army in development of toxic agents. Desire process engineering position in northern U.S. Box 41-12.

EXECUTIVE CHEMICAL ENGINEER—B.S. Ch.E. 40. P.E. Nineteen years' progressive experience in general management, production and engineer, but desire challenging operations management position. Minimum salary $15,000. Box 42-12.

ADMINISTRATIVE CHEMIST—Ph.D. Heavily experienced chemical, biochemical, pharmaceutical fields. Desire position as an assistant to top technical executive in R & D, production, or Latin American management. Box 43-12.

CHEMICAL ENGINEER-CHEMIST—45, B.S. Ch.Eng., 1940, six years' graduate work on petroleum engineering (five publications), electronics and nuclear engineering. Fifteen years' experience chemist, five years' experience development engineer. Gulf coast or central Texas. $8400 minimum. Box 44-12.

LABORATORY MANAGER—Chemist Ph.D., sixteen years' supervision, adminstration, and management of research, development, pilot plants, seeks responsible position pharmaceutical, chemical, or fermentation industry. Box 45-12.

NON-MEMBERS

CHEMICAL ENGINEER—Graduate L.S.U., grade-point average 2.05/3.0. Two years' experience with a large oil refinery in the Southwest. Prefer operations supervision, process design and process control. Particularly interested in a West Coast location. Box 46-12.

PRODUCTION SUPERVISOR — Continental education. Mechanical and chemical background, experience in production of synthetic resin: alkyds, epoxy, polyvinyl, acetate for paints, adhesive and textile finish, varnishes and processing of vegetable oils. Desire responsible position with future, any location. Box 47-12.

PROFESSIONAL SERVICES

Classified . . . EQUIPMENT SECTION

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News and Notes of A.I.Ch.E.

An accounting of stewardship

The final News and Notes column of the year is traditionally a report to the membership on the over-all picture of A.I.Ch.E. and my evaluation of our accomplishments. What sort of year did the A.I.Ch.E. pass through? What are the implications of 1960 for the rest of this decisive decade?

Dynamic objectives

First was the work of the Committee on Dynamic Objectives. The group really got rolling, and the high spot for the committee was a very intensive four-day session in Chicago at which most of the ideas were crystallized and a beginning was made on a report which was presented at the Washington meeting. Owing to the fact that Bob White, the chairman, had to give up his duties, the committee came under the guidance of Don Katz, past president of A.I.Ch.E., who was instrumental in starting the work the year before.

This committee has been concerned primarily with the future of chemical engineering as a whole, which is equivalent to saying the future of A.I.Ch.E. I can safely predict that even if the report should be forgotten the day after it is published, its preparation engendered enough discussion at the meetings of A.I.Ch.E.—in committee and among the membership—to provide a tremendous impetus toward active planning for our profession.

Computation and membership

What were some of the other things we did for the future? The very fine efforts of the Machine Computation Committee must be mentioned. The publication of computer programs is well under way, and we now have three manuals published and two more being edited. The committee presented to Council the possibility of putting into action a machine program for computing physical constants, and this has begun to gather momentum. Also in the field of automation, the Standards Committee came to Council with a proposal to get the publications of the A.I.Ch.E. attuned to a machine program for retrieval of technical information.

One must certainly not forget the fabulous membership year we have had—the best in the Institute's history. More people applied for membership in the A.I.Ch.E. than ever before, and, frankly, as Secretary I feel that this is a cumulative effect of the wonderful cooperation of the membership, of its vital interest in the profession, of the dynamic programs that we are presenting under the direction of the Program Committee and in our Local Sections, and of the messages that we keep transmitting to the chemical engineers the world over about the concern that A.I.Ch.E. has with the discipline and its striving to make it better in a technical sense and in the deeper connotations of the professional aspect of chemical engineering.

As far as technical prominence of the A.I.Ch.E. is concerned, another project instituted this year was the A.I.Ch.E. Petrochemical and Refining Exposition, which will take place concurrently with the New Orleans meeting in February. The philosophy behind this show is to make clear the fundamental importance of chemical engineering in a particular segment of industry—in this case petrochemicals and refining.

Petrochemicals and finance

There is one other great effort that we put into operation during this year, and this has to do with finances. The A.I.Ch.E. is constantly short of funds to do what it wants to do, and this does not come about because the income is dwindling but because the programs are expanding at such a rate that the Institute is hard put to find the wherewithal to finance them. Consequently, when a year like 1960 comes along, with a reduction in advertising income for *Chemical Engineering Progress*, it means sacrifice of program or staff—it was staff in 1960. It means curtailment of activities already in progress. We therefore are trying two schemes to help A.I.Ch.E. finance what it must finance.

One method is the program for endowments. The booklet on endowing the Institute (available to all members) was sent to a selected list of prominent chemical engineers in the hope that in planning the eventual disposal of their estates they would recognize the fact that the profession of chemical engineering has many worthy projects and would benefit from permanent endowment.

The other plan is also a long-term project—to invite members of A.I.Ch.E., when they can, to add an extra amount to their dues at the end of the year for very specific projects that the A.I.Ch.E. has in mind. It is still too early to tell how this program is operating, but we expect to have this type of voluntary contribution—it's all deductible from your income tax—every year on the dues bill and we hope that it produces results.

Finances are a concern because in a rapidly moving, vital profession such as chemical engineering we ought to be able to plan programs which extend for a number of years into the future, and we ought to have the financial backing to see them to their completion.

International year

In the kaleidoscope of the year there were many wonderful things that happened to me personally as Secretary of the A.I.Ch.E. It was an international year for me. First there was the well-received Mexico City meeting with our friends the Mexican chemical engineers, where, besides a fine technical program and a record attendance, there were a number of delightful social events, including a special bull fight, which were greatly enjoyed by the members and their families. Then later in the year I made a flying 14-day trip to Europe to explore developments in the chemical engineering profession there with various representative organizations in England, France, The Netherlands, Germany, and Spain. At Barcelona, as I mentioned last month, the 32 International Congress of Industrial Chemistry was held for an entire week. On America's Day I attempted to outline for the Congress the state of chemical engineering in the United States.

In closing this accounting, I want to acknowledge the inspiration and achievements of president Jerry McAfee and the 1960 Council, and to thank all the members for their fine cooperation and their support of the many projects that they have been asked to undertake. As I noted last year, the members deserve not my thanks but the thanks of the profession as a whole—the thanks of the country—for seeing to it that we are a healthy and professional group supplying the necessary information to keep the American chemical industry well ahead of competition. F. J. V. A.